New York, May 4, 1921 McGraw-Hill Co., Inc. Vol. 24, No. 18, 25c. a copy

CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
Assistant Editor

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

ALAN G. WIKOFF
R. S. McBRIDE
CHARLES N. HULBURT
Assistant Editors
CHESTER H. JONES
Industrial Editor
J. S. NEGRU
Managing Editor

Volume 24 New York, May 4, 1921 Number 18

Sunday Clothes For Chemists' Ideas

THE following is a true story of the proceeds to various parties engaged in the development of a chemical enterprise:

To the chemist for the "idea" together with process and plans	$ 5,000
To the lawyer for legal services in organization	50,000
To the broker for services in floating the new company	100,000
To the owner, net returns in three years	300,000

The chemist, the lawyer and the broker, all three, contributed information. It probably took the chemist longer to see the process through than it did the lawyer to draw up the papers, or the broker to get the subscriptions. But time spent is no gage of the value of professional services. The question is one of intrinsic value. Relatively speaking, the chemist was the parent of the establishment, and the lawyer was its nurse; and outside a divorce court we seldom hear of a nurse who gets all but one and two-thirds per cent of a parent's possessions. There is something wrong in the apportionment of that $55,000. Either the lawyer got too much or the chemist did not get enough. Both contributed professional services. We shall not attempt to bring into consideration as this time the broker's wage. His work is social rather than professional. He knows men, knows how to get their confidence and to induce them to give up their savings. If the owner knew men better he would not need the broker and if the chemist knew men and their ways better he would get a better fee for his own work.

We need more business in chemistry. If a chemist enters the employment of another man or of a corporation, then whatever he discovers in connection with his employment belongs to his employer. We maintain this, no matter how differently some others may feel. But when he becomes consultant the traditions are against him. He is supposed to work by the hour, like a hod-carrier, at cost plus a bare living. Chemistry has the tradition of being cheap and easy to hire.

There is a strategic reason for this. The chemist comes along first. He is the man with the idea. One can take it or leave it, and it is very easy to pass it by. So few persons want the idea that he soon bids against himself to get it taken up. The lawyer comes in when the money has been spent and trouble looms in the offing. He doesn't worry. Whatever happens he gets his reward. And he has learned how to charge for his services. The chemist has not.

Of course there are a great many poor chemists; men of whom negative results may be predicted almost with certainty. But there are also a great many poor lawyers. As such they are trouble-makers, and the wise man does not retain them. He knows lawyers. But he does not know chemists save once in a thousand times; and he is not wholly to blame for it either. He doesn't know how to go about it to find out the best men available.

What chemists need is Sunday clothes for their ideas; silks and satins and scarlet and velvet for the public to admire and desire. Now the art of presenting ideas so that they are desired and regarded as valuable is called business, whether it has to do with selling goods or negotiating loans or securing subscriptions to an underwriting. Chemists need more business in chemistry to make it pay and to give the profession its proper standing among men.

Nutrition and the Road to Pleasant Living

THE Chandler lecture at Columbia University was given this year on April 18 by Dr. F. GOWLAND HOPKINS, professor of biological chemistry, Cambridge, England, on the subject, "Newer Aspects of the Nutrition Problem." Prof. HOPKINS is one of the leading men in the chemistry of nutrition, and it was he who first recognized the necessity of some theretofore unknown accessories to the diet of fats, carbohydrates and proteins now known under the general term of vitamines. A large part of the great gift of the Rockefeller Foundation for research in medical science in England has been set aside for work under Dr. HOPKINS and his associates.

He made an earnest appeal for more work and more workers in this field of supreme importance. The tendency in the last few years, he said, has been for physical chemists to enter the field, and the value of their contributions has been exceedingly great. It enables us to arrive at knowledge which generations have been waiting for, and their methods of reaching results are rapid. In metabolism, however, there are problems which involve chemical reactions that are still unknown, and the distinctions between living and diseased tissues can be learned only by the study of molecular structure; therefore the need extends also for those whose work and experience and habit of thought have to do with organic chemistry.

We noted certain signals of warning to the effect that vitamines have lately come in for more attention and discussion than their functions would seem to warrant, bearing in mind the many other features of similar importance in metabolism. The lecturer also urged us not to forget the differences in metabolism between a large organism such as the body of a man and a small one such as the body of a rat or a guinea pig, in reaching conclusions from experiment.

The social effect of advance in understanding the chemistry of nutrition may be greater than most of us appreciate. Apart from what Prof. HOPKINS told us it would seem to point the way not only toward better

health but toward better living conditions. Suppose it were possible to cut down the cost of wholesome and agreeable foods to a much lower figure than that which now obtains. There are signs of it already. Many men in posts of authority whose rewards for service are so high that the cost of meals is not considered are going over to a much simpler diet than that of the day laborer. The cost of preparation at expensive restaurants is high, but that is due to the accessories such as furnishings, tableware, table linen, service, including high rents, more than to the food, or even to its preparation.

This brings us around to a favorite thesis, to the sermon we have been preaching for several years past, and that is that the road to pleasant living is not through wealth, but rather through interest and curiosity. The interest to which we refer is not the earning power of bonds, but the same word in another sense—to wit, the quality of interest in various topics which is akin to curiosity. Therefore whoever has an intellectual ambition, or whose interest in any subject within the arts and sciences is aroused, he may work by the day and yet be a remarkably free man. When the day is over, his task is done and the best of art and literature is open to him. This is not the case of the employer or those with creative intellects whose work is never done, and who cannot address themselves with the same seriousness to the graces of life. Their spare time is not really free. True, art and literature have a hard time these days among those who belong to what is technically known as the ranks of labor, but these same ranks of labor have the golden opportunity to advance themselves in scholarship, in learning and in the newer humanities. Therefore a possible concomitant of research in nutrition may be a very widespread and distinguished culture among those who work with their hands.

The Overtones of Efficiency

IN THE May number of the *North American Review* a member of our staff presents a popular essay on "Relativity and Life." The thesis is that relativity has been known as a philosophic concept for many years, but that EINSTEIN was the first to present it as a scientific principle in which dimensions are determined and eventually measured and compared. It is proposed that this may be done in fields more generally familiar than that of cosmic physics, and dimensions are sought for liberty and other ideas which are under daily discussion. It is held that the dimensions of liberty are freedom and service; that freedom is a more restricted concept than we generally admit, and that without service, rendered either by ourselves or by others, we cannot enjoy liberty. Rights are declared to emanate from liberty, to rest on liberty, and it is maintained that there is no such thing as a single or independent right. In resting on liberty, rights also rest on service, which is a dimension of liberty.

It is possible that this postulate may aid us in planning work. In the consideration of service we have not been disposed to measure it; our disposition has been to get as much of it as we can at the lowest cost. Or, if we render service, it has been our disposition to get as much as we can for it, irrespective of its measurement. What we have neglected is the *obligation* of service. We think so little of the obligation of service that it does not enter into the romance of our generation; we do not find it save on rare occasions, in fiction or in the drama or in moving pictures. The most frequent idea seems to be that if some hero or heroine is pleasing and affable and does the day's work acceptably, then the reward is a great inheritance of wealth which in turn is a reward of service that has been rendered by somebody else.

The jingle of dollars, however, is not enough to hold the public attention. The public demands more of human interest than a bank account or a big storage vault for securities. So there is introduced what is technically called heart interest, which is usually sex interest, and everybody is satisfied when the hero and heroine, one of whom is rich and the other poor, agree to get married.

Now we do not want the drama's conventional heart interest in industry, and yet we do need some kind of a real heart interest in it. We need something in every organization that will induce every one connected with it to desire to give service for a cause.

If we compare a present-day stone mason with one of the thirteenth century we find the modern mason getting better pay, working shorter hours, but wholly indifferent to the building he is working on. He doesn't know and doesn't care what the building is to be. The foreman has blueprints to guide him in directing the work, and the easier it is the better everybody likes it. It is less "bother" if it is easy. The mediæval mason, on the other hand, knew all about the building, knew its purpose, knew he was building for time, had opportunity to exercise his own ingenuity in carving as well as laying the stone, and he was doubtless proud that he had a hand in the work.

In industry it behooves us to seek its purpose, the purpose that makes it so desired that the product is wanted. If a man cannot be proud in having a hand in his work, there is something lacking. Industrial life needs larger thinking than it has enjoyed: more thinking and less belligerence.

As a rule labor is still unwilling to take chances on production. Labor and employers can agree on a minimum wage and an interest in profits, but when the profits go down labor usually strikes at the reduction. It isn't always so, but it happens too often to make profit-sharing a workable practice, even when employees would welcome it. But beyond the wages there is something needed to encourage service. It is a perplexing question, but that is what makes it interesting. This is the overtone to the jingle of dollars, to the commodity price paid for work. It could even be mathematically expressed if we knew it better.

If we bear in mind that our liberties and our rights emanate from services, our own or those of somebody else, it will make us all less bumptious in our claims and more willing in our work. We cannot as American citizens live upon the liberty achieved by the founders of the republic. We shall use it up in no time unless we ourselves do constantly contribute; contribute more than we require for ourselves. We cannot run away from our obligations.

The trouble is that we do not learn what our obligations are by having them preached at us. We must discover them for ourselves. We are more inclined to do this when we see somebody else seeking and finding his responsibilities and fulfilling them. To sense obligations and to fulfill them is an achievement in character rather than an art or an inheritance. Right conditions induce it, and to find and provide the right conditions is the greatest problem in industry today.

Federal Trade Commission Accepts Judge Gary's Invitation

FORMAL complaint has been issued by the Federal Trade Commission against the Steel Corporation and its subsidiaries, alleging unfair methods of competition in violation of section 5 of the commission's organic act and section 2 of the Clayton act. The complaint is made upon application of the Western Association of Rolled Steel Consumers and other users of steel products, and is the outgrowth of conditions complained of by more than 2,700 fabricators of steel in the Chicago, Duluth and Birmingham districts, by legislatures of three states, by several municipalities and by chambers of commerce and by many business organizations.

In brief, the applicants complain against the device known as the Pittsburgh plus price. Under this device all steel except rails, wherever made and whether made by the Steel Corporation plants or by independents, is sold at the Pittsburgh price plus an amount equivalent to freight to point of destination, irrespective of whether the cost of production at the plants outside of Pittsburgh is less, as it generally is, than the cost of production in Pittsburgh. The "Birmingham" price is also complained of, which is described as the Pittsburgh price plus an additional charge of $5 a ton.

The complaint charges that the Steel Corporation has complete control, supervision and direction over the subsidiaries, transportation materials used in the manufacture of iron and steel and products made therefrom in interstate commerce; that the corporation through certain of its subsidiaries owns and controls over 75 per cent of the total iron ore deposits in the Lake Superior district, where is located the greater part of the iron ore deposits of the United States; that it owns and controls the greater part of the iron ore deposits of Alabama, where production is second only to that of the Lake Superior district; that it owns and controls the ultimate iron ore supply of the United States; that it owns and controls the major number of railroads and lake transportation systems which carry iron ore from mines to manufacturing plants of its subsidiaries and their competitors, and that it likewise owns and controls coal mines and limestone quarries necessary in the manufacture of steel.

The complaint charges that of the total production in the United States of the following items respondents manufacture and sell approximately 47 per cent of the crude steel in the form of ingots; 45 per cent of semi-finished rolled steel in the form of billets, blooms and slabs and sheet and tin plate bars; 45 per cent of finished rolled iron and steel products in the form of rails, plates and sheets, structural fabrics, bars, iron rods, skelp, hoops, bands, cotton ties, etc., and 60 per cent of other steel products.

Paragraph 5 of the complaint charges that the corporation for at least seven years has issued from time to time price quotations and schedules covering rolled steel manufactured by its subsidiaries and that these quotations are adopted by all the subsidiaries and their competitors substantially as their prices.

Paragraph 5 also recites that because of the power and influence of the corporation through the large percentage of the steel-manufacturing business done by it and supported by it the consequent potential power to embarrass or destroy its competitors by unduly lowering its price schedules is tantamount to the naming by the Steel Corporation of prices that are to be charged by all steel manufacturers in the United States.

This proceeding by the Federal Trade Commission was urged by Judge GARY, chairman of the board of the Steel Corporation, at a preliminary hearing in Washington on July 9, 1919. When questioned by the commission at that time as to whether he thought it had jurisdiction, he replied affirmatively and that it was a question that ought to be taken up and settled by the commission. He added: "It is one of the most important questions you ever had before you, or ever will have before you." He also said that the principle of the Pittsburgh plus price plan was duplicated in whole or in part in a great majority of the other basic industries of the country.

Of course, the substance of the complaint is: Pittsburgh, the high-cost-producer, gets the bulk of the business at a profit arbitrarily decreed; plants elsewhere get additional profits because of their lower costs of production; every increase in transportation rates means additional profits to the plants outside of Pittsburgh, because the amount of the increased rate is added to the selling price.

The investigation has been invited by the head of the Steel Corporation. The invitation has been accepted by the Federal Trade Commission. It is well that it should proceed. If, as Judge GARY says, the practice is followed in the other basic industries of the country, such should be brought out. If it is a good thing, its wisdom should be established. If it is not, but makes merely an added burden which the consumer has to pay, its abolition should be decreed, not only in the steel industry but in all others where it prevails.

Artistic Influence In Scientific Development

The Past as clear as Polished Glass appears
While Dark as Lacquer seem the Coming Years;
Yet, mirrored in the Past, the Eye may see
The Faces of the Centuries-to-Be.

FAR back in the dim ages as the time may have been when the potter first employed his hands to coil character and clay into expressions of beauty he developed a spirit of accomplishment which has been handed down to our present day ceramists. With this tradition of idealism in their hearts a few of today's old-timers assembled some twenty years ago and founded the American Ceramic Society.

Now a large national organization, its principal activities are centered on the application of chemistry and physics to technical problems, and human understanding to problems of organization and trade development in the clay-working industries. That this same influence carries the work along and that the ceramists are anxious to preserve it to future generations was crystallized in the formation of a new art division of the society at the annual convention in February.

Other events at this meeting plainly indicated the field of the future in the bringing of the heavy clay industries together for research into methods of scientific control, in the pleas that manufacturers forego degeneration consequent upon secrecy of process, and in the plans for broadening of business activities to an international scope.

The trend of the growth of American ceramics clearly appears in many details and it may be definitely predicted that the ideals of the artist will be a continued constructive influence in the scientific development of the calling.

Readers' Views and Comments

Activities of Fixed Nitrogen Research Laboratory

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with much interest the article by Dr. R. C. Tolman on "Government Fixed Nitrogen Research" in your journal of April 6, 1921, page 595, and feel myself obliged to comment upon some of the propositions inferentially laid down by Dr. Tolman.

In order to clear the ground I may say that I believe as firmly as Dr. Tolman does that research in the problem of fixing nitrogen is the most important thing at present before the world. It is an old saying, and probably a true one, that what enabled us to pay off the debt of the civil war and cure inflation by "resumption of specie payments" was the invention of the twine binder, which, together with the unoccupied lands of the West, enabled us rather suddenly to make an immense addition to our productive power. All the world is at present staggering under war debts; and the man who makes "two blades of grass grow where one grew before" is more than ever a public benefactor. He is wanted by all the world. To clear off these debts quickly, not only in this country but all over the world, we need again an immense increase in production; and one way to get it is to grow more food to support more workers in industry. This can be done by cheaper fertilizer enabling the farmer to make a decent profit from cheap food.

Without going into the question of how far this necessary research work should be done by the Government and how far it should be done by private enterprise, I may say that any information that expert skill in the service of the Government can contribute toward this matter is welcome—welcome to all of us. It should, however, be noted that in this country experience teaches us not to be very sanguine as to Government activity in business.

Where I differ from Dr. Tolman, in the first place, is in his assumption all through his article that the results which his laboratory obtains may properly be kept secret from the public. As he states it, if the Government is to run certain plants, then and in that event all results of his work are to be kept "confidential"; which means that they are not to be disclosed to the public at large. Now I personally have a very vivid interest in the problem of fixing nitrogen, and I am a taxpayer. I feel that the results of Government work in this line, if any, should be made public and not held in secret archives of the Government. I must therefore register a protest against any such policy of bureaucratic secretiveness.

Secondly, I must question the choice of lines of investigation. Mainly this research work is to be done upon the cyanamide and the Haber processes. Now as it happens both these matters are more or less covered by patents. Is it the proposition that the Government is to do work in this line which is to be kept secret from the public and which either will inure largely to private benefit—namely, to those gentlemen who happen to have a financial interest in the Haber process and in the cyanamide process—or else will form the basis of Government competition with such interests?

I also dissent on general principles from the idea that this work shall be mainly limited to these two lines. The cyanamide process, Dr. Tolman states, is at present "the only means by which nitrogen can be fixed in America in case of emergency"; but he also virtually admits that after a while it must be dropped. With the latter admission I am in accord. For generations the price of inorganic nitrogen for fertilizer purposes has fluctuated around 15c. per lb., that being the datum plane set by Chilean saltpeter. About 3c. a lb. being the Chilean export duty, we are now, on a consumption of 200,000 tons of nitrogen, annually paying tribute of about $12,000,000, partly to Chile, but mostly to help make it interesting to capital to invest in byproduct coke ovens (illustrating, by the way, the workings of protection). Very little of this tribute goes to the cyanamide interests. Even with such stimulation, the only cyanamide plant operating in America after about fifteen years of development is in Canada. If we may set 5c. nitrogen as a goal of fixation activity, it is pretty certain that we must find a faster vehicle than the cyanamide process.

Taking the second main proposition, the Haber process has already been worked out very well in Germany and I do not know that there is any great secret as to the results which the Germans get. They appear to be still some distance from the 5c. mark. Various private interests in this country now know as much on paper as the Germans do. I therefore very much question the advisability of spending Government money for duplicating this information, and particularly if the information is to be kept "confidential." If not kept confidential and used in competition with private enterprise it will inure to the benefit of my friend the General Chemical Co., which knows most of it anyhow.

Dr. Tolman is perfectly sound in his reluctance to go very far into the arc process; but feeling as he does, I am surprised that he is putting even $14,000 into equipment for it. I would suggest that $14,000 spent in Norway would probably bring more information than $14,000 spent here. It is a truism in research work that it is better to start things where the other fellow left off; and in Norway they have spent many dollars and much time in learning about the process.

Finally, I must take exception to the casual way in which fixation in the form of cyanide is dismissed. While it is perfectly true that the Bucher process got into trouble because of the inherent difficulty in transmitting large amounts of heat through a retort wall to an open and pervious charge undergoing endothermic action, yet the fact remains that cyanide formation is, so to speak, the only way of fixation to which nitrogen seems to take naturally and easily. In other ways nitrogen must be bludgeoned into combination by electricity or pressed with the very purest of hydrogen, but into cyanide the nitrogen goes because it seems to feel like it. The energy involved is about 8,000 units, suggesting a material and fuel cost under ½c. a lb.

A cyanide process makes rather intriguing promises. I might recommend that Dr. Tolman, if he is going to continue these investigations, pay more attention to

cyanide and less to other things; but again there is the inherent difficulty that if he does so the results either will injure or will benefit private interests. Yet, even so, on the principle of equal opportunity and non-discrimination, I am constrained to suggest that a fair share of any appropriation for nitrogen fixation be devoted to the development of the cyanide method.

Ferro Chemicals, Inc., Washington, D. C. R. FRANCHOT.

SIR:—The Fixed Nitrogen Research Laboratory always welcomes constructive suggestions, such as Mr. Franchot's, as to the policy which it should adopt.

With regard to Mr. Franchot's first suggestion, I may say that the War Department has kept the results of the work of the laboratory confidential in order that they might be available solely to the U. S. Fixed Nitrogen Corporation, which was contemplated in the Wadsworth bill, which failed to pass during the last session. Assuming that the failure of this bill means that the Government is not itself going to undertake the fixation of nitrogen, it is obvious that there is no longer any necessity for keeping the researches of the laboratory secret. In fact, the laboratory has no justification for existence unless the information which it obtains is put to some useful purpose, either by the Government or by private industry, and the laboratory is now definitely recommending to the War Department that the results of its researches be published.

With regard to the relative amount of attention which the laboratory has paid to the different methods of nitrogen fixation, the greatest emphasis has in the past been put on the cyanamide and the Haber processes, in order that information should be available for the governmental operation of the Muscle Shoals plant, which at the time the laboratory was founded seemed probable, and in order that the Haber plant at Sheffield might be reconstructed.

In the future more emphasis will be put on other methods of nitrogen fixation, and as a matter of fact for some time the laboratory has been planning work on the cyanide process. RICHARD C. TOLMAN.

Fixed Nitrogen Research Laboratory, Washington, D. C.

Commercializing Priestley's Theory

To the Editor of Chemical & Metallurgical Engineering

SIR:—Your recent article and correspondence anent the subject of "Easy Money From Peat"* recalled to me a similar experience which I had a few years ago, which may be of interest in this connection.

I was called upon to investigate the composition of a liquid being widely promoted as a carbon remover for gasoline engines. The action of this liquid was claimed to be due to its property of liberating *gaseous oxygen* when submitted to a *pressure* of 50 lb. or more. When mixed with the gasoline in the proportion of about 1 oz. to 5 gal. sufficient liquid was supposed to be carried into the cylinder with the vaporized gasoline to compensate for the large volume of nitrogen in the air of a combustion mixture by means of this oxygen!

Upon casual investigation this truly remarkable substance seemed to be composed chiefly of kerosene with small quantities of naphthalene alcohol and amyl acetate common to similar preparations.

The quantity of oxygen claimed to be liberated was, if I remember correctly, not less than 10 liters per cubic centimeter! Aside from the improbability of any substance decomposing in this way under the influence of pressure, which would naturally tend to have the reverse effect, I attempted to point out that such a volume of oxygen would weigh considerably more than the total weight of the liquid from which it was obtained, but found that this apparent difficulty had been disposed of by the ingenious inventor. I was gravely informed that "according to the Priestley theory" pure oxygen possessed no weight whatsoever, the mass ordinarily found associated with this substance being due entirely to impurities therein.

Upon the failure of the technical experts of this project to put in an appearance at several conferences and demonstrations which we attempted to arrange the subject was dropped, but it seems unfortunate to allow modern chemical science to struggle along without the marvelous benefits which would doubtless accrue from the judicious application of the "Priestley theory."

New York City. GUSTAVE REINBERG, JR.

*See CHEM. & MET. ENG., vol. 24, Nos. 5 and 12, pp. 213 and 506, Feb. 2 and March 23, 1921.

Important British Fertilizer Supplies

Up to ten years ago the names of the Island of Nauru and Ocean Island were practically unknown to any save the geographer and the specialist. They are tiny specks of land lying in one of the loneliest spaces of the Pacific Ocean fifty miles south of the Equator and 3,000 miles west of the South American coast.

In 1885 these islands, which were considered of no commercial value, were formally annexed by Germany. Some time afterward phosphate deposits were discovered on Ocean Island and some years later on Nauru. One of the effects of the world upheaval of August, 1914, was the formal transfer of these German islands to Great Britain under the terms of a mandate. An agreement was made on July 2, 1919, between the governments of the United Kingdom, the Commonwealth of Australia and the Dominion of New Zealand for the allotment of British-controlled phosphates in the Pacific Ocean on the basis of 42 per cent to the United Kingdom, 42 per cent to Australia and 16 per cent to New Zealand.

It now appears that the British Empire has acquired one of the richest supplies of phosphates in the world, reports Commercial Attaché Dennis, of London. It is stated that the formation of these phosphate deposits has been accomplished largely through the agency of fish-fed sea birds which have left vast deposits of guano on the islands. These deposits, mingling with the lime of the coral rocks, have practically converted the whole of the islands into great repositories of phosphate of lime. These phosphate deposits run to a depth of 40 ft. on Nauru and 57 ft. on Ocean Island. A representative sample of this island phosphate yields:

Moisture sample:	Per Cent
Water	3.87
Tribasic phosphate of lime	82.56
Ground sample (dried):	
Carbonic acid	2.06
Equal to carbonate of lime	4.69
Phosphoric acid	39.34
Equal to tribasic phosphate of lime	85.89
Oxide of iron and alumina	0.76
Organic matter and combined water	2.86

Neither island possesses harbor facilities. It has been necessary, therefore, to construct jetties, of the cantilever type, running far out over the reefs. From these the phosphate is lightered to steamers. The present annual production of the islands is in the neighborhood of 250,000 tons.

Italian Chemical Industries

FROM OUR SPECIAL CORRESPONDENT

GENOA, ITALY, April 15, 1921.

THROUGH the large quantities of German war reparation chemicals and dyestuffs delivered to Italy this country was not only overstocked with some products but the national producers suffered severely through the great reduction in the prices that followed. Therefore a movement was begun to stop or at least reduce the supply of some of these products from Germany, and replace them with others of which Italy is still in great need.

FOREIGN EXCHANGE SINKS STRONGLY

After several months of very high foreign exchange, that had demonstrated only a very slight tendency toward reduction, a sudden fall took place toward the middle of March, bringing down with it all prices. Business, already very dull, came in many cases to a complete standstill, old stocks being used up by many, while others suspended manufacturing operations awaiting events. Italian metals, minerals and chemicals received a further fall, and so did Sicilian products such as sulphur, essences, sumac leaves, manna, mannite, tartaric acid, citric acid, cream of tartar, etc., creating a panic among holders of such products, many of whom tried to sell their stocks, often not finding buyers.

NEW DECREE ON BENZENE FOR CHEMICAL WORKS

To assist and encourage manufacturing operations where benzene is employed largely, the Italian Government has arranged a specially reduced importation tariff of two lire per 100 kilos on benzene and other light coal-tar oils destined to serve as raw materials for the production of artificial organic coloring matters or varnishes and similar products. Such benzene must, however, be submitted to a certain degree of adulteration at the expense of the buyers. The adulterant will be established for the different industries by the Minister of Finances.

NEW WATER-POWER AND HYDRO-ELECTRIC DEVELOPMENTS IN ITALY

Different projects are being studied for utilizing the water power available in the Trentino. One proposal is to form an independent corporation controlling the property of different Italian and Tyrolese industrials and of several municipalities, and another is to utilize the Noce Torrent, collecting a portion of its waters in a large reservoir in the Palu Valley and a portion in a second reservoir constructed between Pelizzano and Mezzana. The extensions of fields and woods would thus be occupied by two large artificial lakes, and the valley of Palu would be dammed by a stone dike 75 m. high and 65 m. thick, inclosing a volume of water of a possible volume of 38,000,000 cu.m. (about 50,000,000 cu.yd.), covering a surface of about 900,000 sq.m. (about 1,100,000 sq.yd.). The water power derived from these lakes would permit the production of 150,000 to 180,000 electric horse power.

Development of the Italian hydro-electric companies has increased considerably. Although these once possessed a total capital of only 600,000,000 lire, today their capital is 1,500,000,000 lire, an increase of 180 per cent. The Italian Government gave no support in this instance; on the contrary it receives 70,000,000 lire per year in taxes and other fixed rights. During the five years 1915-1920, 265,000 electric horse power obtained from new hydraulic plants was put in operation, and at present plants are under construction for harnessing more than 400,000 horse power. The capital needed to bring to completion similar plants is calculated at 1,200,000,000 lire. Other plants are also in contemplation to bring into being another million horse power.

TECHNICAL DIRECTORS MEET

At a meeting in Milan recently of the new association of technical directors, to which members came from Piedmont, Liguria, Lombardy, Veneto and Emilia, the industrial and financial situation of Italy was closely examined, and it was generally conceded that the labor-control experiments conducted in some works only tended toward general disorganization and to a loss of authority and initiative on the part of technical directors and industrials. It was decided to call the attention of all absent technical directors to this state of affairs in the hope of getting their co-operation in solving the problem.

A CONVENTIONAL EXCHANGE

The use of a conventional, or reduced, foreign exchange with England and France seems to have taken a certain development during March. A similar arrangement appears, however, to have been made by many Italian and foreign firms for the last six months and during the war whenever the exchange made a great increase that would have stopped or reduced business. Many foreign exporters could thus conduct their business as in normal times and without great danger of loss. By this arrangement the buyer deposits to the credit of the foreign sellers in an Italian bank the value of the goods purchased at a reduced exchange arranged by both sides. This deposit then remains in Italy until it is most profitable for the seller to draw it out. The foreign seller does not, however, lose the use of the whole sum, for he can obtain from any bank in his country a loan of 75 per cent on it, and at the worst loses only the difference of interest on the foreign loan and Italian credit.

ITALIAN FERTILIZERS

The serious difficulties encountered in the supplies of fertilizers, and especially of perphosphates, decreased considerably during March, owing to greater activity on the part of Italian fertilizer works, which began the construction of new works and extended older works. Italian production of sulphate of copper and of nitrogenized fertilizers such as cyanamide, nitrate of ammonia, etc., was also increased and much improved.

ITALIAN LITHOPONE INDUSTRY

The manufacture of lithopone is conducted in only one works, at Brescia, belonging to the Milan firm Attilio Gelpi, which produces only a few hundred kilos per day, although the zinc and barium minerals necessary are particularly abundant. For this reason the greater part of the product used here has to be imported. During March a campaign was begun to increase the production of this important substitute for carbonate of lead, and it is hoped means will be found for large future developments. This would seem to be an excellent opportunity for the investment of American capital. Germany is already trying to do something in this direction, but her initiative is not looked upon with favor. Before the war the zinc and barium minerals were largely exported. This is, however, no longer profitable, owing to the high transportation expenses.

The Crystalline Structure of Metals

A Brief Definition of Crystallinity; a Discussion of the Methods Used in X-Ray Analysis of Atomic Spacing; and a Statement of the Results of Such Studies Made to the Present Time

BY ZAY JEFFRIES AND R. S. ARCHER
Research Bureau, Aluminum Company of America

IT IS PERHAPS because we are accustomed to associate regularity of external form, brittleness and transparency with the crystalline state that it seems somewhat strange to regard ordinary pieces of metal as crystalline. The essence of crystallinity, however, lies in regularity of internal structure, and it has been abundantly proved that all metals are crystalline. Study of their crystalline structure has led to very clear conceptions of the mechanism of deformation and failure, and recently to a general theory of the strength of alloys.[1] The application of X-ray analysis has made our knowledge of crystal structure more complete and exact, and is clearly destined to play an important part in the future development of metallographic science.

Crystallinity depends upon an orderly arrangement of the molecules of a substance. In the molten condition or in solution in a solvent the molecules are arranged in an entirely haphazard manner. On the other hand, when the substance crystallizes, the molecules group themselves according to definite and repeating patterns. Metals are monatomic—that is, their molecules contain only one atom. The case under consideration in this paper is thus simplified in that the atom is the unit in the pattern.

SPACE LATTICES

The pattern which forms the foundation upon which a crystal is built is known as a *space lattice*. It consists of a series of points in space such that every point is situated similarly to every other point. Space may be imagined as divided into cells by three sets of parallel planes. The planes of each set are at equal distances from each other and parallel; the distance between planes may be different in the various systems, and the three sets of planes may make any angles with each other. The points of intersection of these planes constitute a space lattice, as is illustrated in Fig. 1.

The arrangement of atoms in planes is responsible for the characteristic and commonly observed properties of crystals. For instance, when a crystal is allowed free development, it assumes a form bounded by plane faces. The direction, or orientation, of these faces is determined by the lattice underlying the crystal. Similarly, it is found that crystalline bodies often possess the property of breaking easily along certain planes, called cleavage planes. Deformation of metals takes place by sliding on planes known as slip planes, as will be described later. In any given crystal the orientation of the cleavage planes and slip planes is fixed. When a crystalline substance is subjected to attack by a chemical solvent, it is found that the resistance to solution is greatest on certain planes. The planes determining external form, cleavage, slip and resistance to chemical attack are planes which pass through atom centers in the space lattice. It will readily be seen that a very large number of sets of parallel planes could be drawn which would pass through all of the atoms, but the significant planes are limited to those on which the concentration of atoms is large.

SYMMETRY

Any plane passing through a crystal in such a way that the atoms on one side occupy the positions of mirror images of those on the opposite side is a *plane of symmetry*.

Two kinds of planes of symmetry are distinguished. If the structure on one side of the plane can be rotated on the plane through some angle (other than 180 deg.) without destroying the symmetry, the plane is said to be a *principal plane of symmetry*. If such rotation destroys the symmetry for all positions other than the

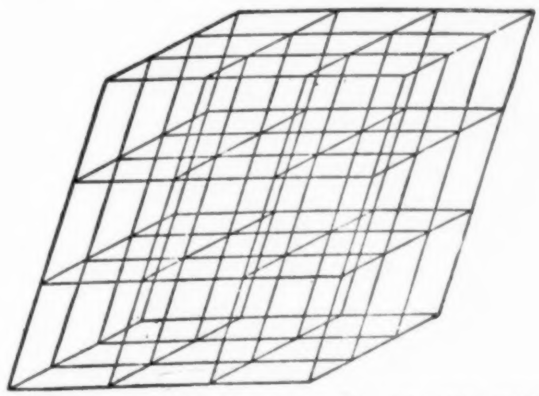


FIG. 1. THREE SETS OF PARALLEL PLANES WHOSE INTERSECTIONS FORM A PARTICULAR SPACE LATTICE (BRAGG)

original or one reached after a rotation of 180 deg. then the plane is called a *secondary plane of symmetry*. To express this more mathematically, principal planes contain two or more equivalent and interchangeable directions, while secondary planes possess no interchangeable directions.

An axis of symmetry is a line through a crystal such that a revolution about it through some angle less than 360 deg. will result in a duplication of the original position of the crystal. The degree of symmetry with respect to the axis depends on the number of times during a complete revolution that such duplication occurs. When such a condition is brought about by a revolution of 180 deg., or twice during a complete revolution, the crystal is said to possess a twofold or binary symmetry. Similarly the classification is extended to threefold or

[1]This theory, which the authors have called the "slip interference" theory, will form the subject of another article to appear soon.

ternary, fourfold or quadratic, and sixfold or hexagonal symmetry. Axes of more than twofold symmetry are called principal axes of symmetry. Twofold or binary axes are called secondary axes.

In considering their structural characteristics, crystalline bodies are looked upon as extending indefinitely, in all directions. The planes and axes referred to represent directions rather than specific planes or lines. Other planes through atom centers parallel to a plane of symmetry are likewise planes of symmetry of exactly the same kind. When we say that the isometric system possesses three principal planes of symmetry, we mean that there are three sets of parallel planes any one of which is a principal plane of symmetry for a crystal extending indefinitely in all directions.

Isometric or Cubic System

The direction of a crystallographic plane is defined by referring it to a system of axes chosen with respect to the particular crystal system under consideration. The cubic or isometric system, which is the simplest and also the most common among metals, will serve to illustrate the method of designation. Axes *OX*, *OY* and *OZ* (Fig. 2) are in this case the intersections of the three principal planes of symmetry. They are perpendicular

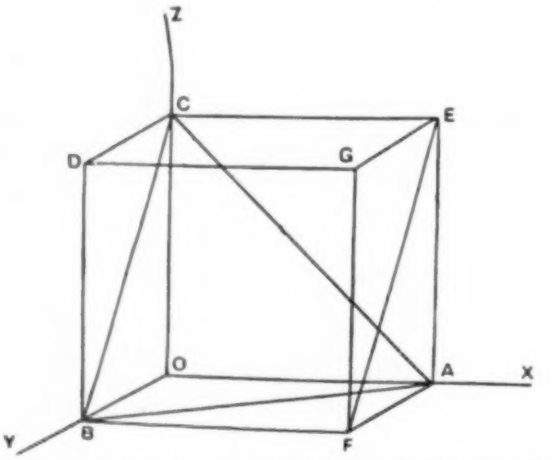


FIG. 2. SKETCH OF CUBIC CRYSTAL ILLUSTRATING SYMMETRY (BRAGG)

to each other and are said to be of equal length, meaning that the same scale is used to represent distances on all the axes, and there is nothing inherent which distinguishes one from the other.

Plane *ABC* is called the ground plane. In all systems one of the parameters[2] of the ground plane is taken as unity for simplicity of reference, and the other parameters are then fixed in accordance with the nature of the system. In the isometric system all of the parameters of the ground plane are equal, and hence unity and plane *ABC* intersects all axes at equal distances from the origin.

The *indices* of a plane are the reciprocals of the parameters, and planes are more usually designated by indices. The planes noted in Fig. 2 have indices as follows:

ABC	(111)	*CEBF*	(011)
CDGE	(001)	*DGBF*	(010)

The directions of *OA*, *OB* and *OC* in Fig. 2 are considered positive, and the opposite directions negative. If the parameter of a plane is negative, then the corresponding index is negative and it is written with the negative sign above the index. If the parameters of a certain plane are $OA = -2$, $OB = 1$, $OC = 1$, the indices are $\bar{\tfrac{1}{2}}$, 1, 1. Since, however, indices and parameters express only ratios, not the actual position of a particular plane but the direction of a series of parallel planes, the indices ($\bar{\tfrac{1}{2}}$, 1, 1) are the same, crystallographically, as ($\bar{1}$, 2, 2), ($\bar{2}$, 4, 4), etc. Writing without commas, ($\bar{1}22$) is used because it has no fractions and has at least one index unity. The above system of notation is the Miller system.

Crystal Systems

All possible crystal structures can be divided into six groups, each characterized by a particular grade of symmetry[3]:

1. *Isometric or Cubic System.*—Three principal and six secondary planes of symmetry. Crystals referable to three equal rectangular axes. Most metals belong to this system.

2. *Tetragonal System.*—One principal and four secondary planes of symmetry. Crystals referable to three rectangular axes, only two of which are equal. No metals are definitely known to belong to this system, with the possible exception of tin.

3. *Hexagonal System.*—One principal and six secondary planes of symmetry. Crystals referable to four axes, three of which lie in the same plane intersecting at 120 deg., and are equal in length. The fourth axis is perpendicular to the plane of the three others at their intersection and may have either greater or less length. The metals magnesium, zinc and cadmium belong to this system.

There are three other systems—namely, orthorhombic, monoclinic and triclinic, in which no metals are known to crystallize.

Visible Metallic Crystals

Under some circumstances the crystalline nature of metals becomes apparent to the unaided eye. The crystalline appearance of the zinc on iron galvanized by the hot dip process is familiar to everyone. Similar regularity of external form is frequently produced when metals solidify with one surface free from restraint. Fig. 3 shows the surface of a piece of cast tellurium which solidified in an open mold.

During solidification of a metal crystallization begins at centers called nuclei, and proceeds in a directional manner. Growth is most rapid along some line which bears a simple relation to the symmetry of the crystal. A trunk shoots out in this direction and branches grow out from the sides of the trunk parallel to one another and in directions determined by the structure of the crystal. The result is a formation which from its resemblance to a tree is called a *dendrite*. The dendritic appearance of many of the crystals can easily be seen in the photograph of tellurium, Fig. 3. Because of the fact that most metals contract on solidifying, the dendrites which form on the surface of a metal are left in relief by the contraction of the mother liquor.

Since several nuclei form simultaneously and growth proceeds in all directions (especially when the nuclei are completely surrounded by the molten metal), it is obvious that adjacent crystals growing toward one an-

[2]The parameters of any plane are the intercepts on the axes of reference. The parameters of plane *CDGE*, for example, are ∞, ∞ and (*OC*) = 1.

[3]"Elementary Crystallography," by W. S. Bayley; McGraw-Hill Book Co.

FIG. 3. FIR-TREE CRYSTALS ON SURFACE OF CAST TELLURIUM. × 2

other must meet. If a single crystal is allowed to develop from a molten bath, its external shape will be a fairly perfect geometrical figure. With a large number of growing crystals, however, as the molten metal becomes exhausted the crystals must meet in such a manner as to fill the space completely. These crystals will be oriented in different ways, and hence in order to fill space cannot form their habitual external shapes. Such a crystal with orderly arrangement of the atoms in the interior but an external shape determined by the influence of other crystals is called an *allotriomorphic crystal*, or *crystallite*, or more commonly a *grain*. In any given grain, therefore, the atoms are arranged in the same manner as they would be in a perfect crystal of the metal, but the grain may have any external shape.

No two adjacent grains in a cast metal have the same orientation. By orientation is meant the direction of the crystallographic axes. If two adjacent grains had the same orientation, the boundary between them would disappear and the two grains would become one. A metal, therefore, which has solidified from the molten state consists of an aggregate of differently oriented grains. These grains vary widely in size and shape, according to the specific crystallizing properties of the metal itself, the rate of cooling through the solidification range, the temperature gradients, purity and other factors. Sometimes the grains are so large that they can readily be seen with the unaided eye and at other times they are so small that a microscope is required to see them.

Etching Polished Sections

For examination under the microscope a piece of metal must be ground or filed flat and then carefully polished. Examination then reveals no structure whatever, except for particles of included foreign matter such as slag and oxides. The boundaries of the grains themselves are not distinguishable. It has been suggested by Beilby[4] that the process of polishing has produced a surface layer of amorphous metal which is opaque and covers the crystalline metal underneath. This amorphous layer can be dissolved in a chemical reagent in which the metal is soluble. The process of chemical attack on the polished surface is called *etching*. The boundaries between the grains are regions of low resistance to chemical attack and their location is shown after light etching.

Deeper etching develops marked differences in color between different grains, some appearing dark and others light. The process of solution produces minute facets, which vary in orientation from one grain to another. Light falling on an etched surface will be reflected into the microscope only by such facets as have the appropriate orientation. These grains will appear light, while other grains will appear darker. The different tints of the grains are therefore evidence of their crystallinity and of their different orientations.

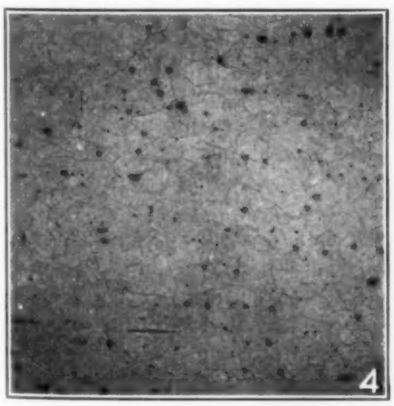
Still deeper etching often produces within certain grains geometrical figures which are called etching pits. These pits approximate a definite geometrical form, such as a triangle or rectangle, and within any particular grain have the same form and orientation. They furnish additional evidence of the crystallinity of metals.

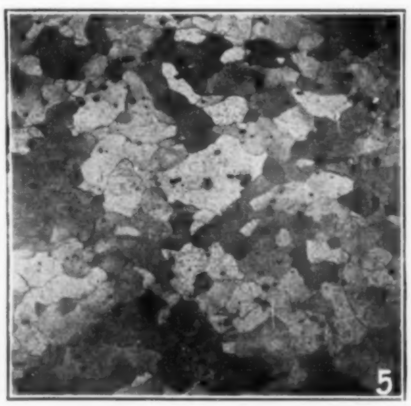
The various effects of etching just described are shown in Figs. 4, 5 and 6, taken from a specimen of nearly pure iron (Armco iron).

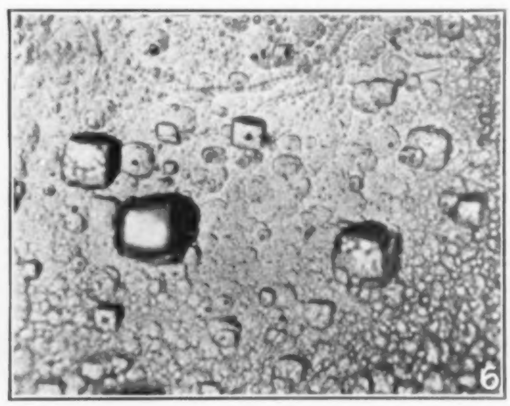
Intracrystalline Slip

If a piece of ductile metal is polished and etched to bring out the grain boundaries, and is then subjected to a load which causes a slight permanent deformation, examination under the microscope reveals systems of parallel lines running across the grains. In any one

[4]"The Hard and Soft States in Metals," by Sir George Beilby; May lecture, Institute of Metals, 1911.







FIGS. 4, 5 AND 6. ARMCO IRON, AFTER VARIOUS ETCHINGS

Fig. 4. Light etching, developing grain boundaries. × 40

Fig. 5. Moderate etching; various grains having different tones. × 40.

Fig. 6. Deep etching, developing so-called etching pits. × 800.

grain the lines are approximately straight and parallel to one another, but their direction is different in different grains. In the first stages of deformation only a few of these lines appear, and not in every grain. As the deformation increases more lines appear, becoming closer together and appearing in grains previously free from them. Finally other sets of lines are developed, parallel to one another in any one grain and crossing the first set of lines. Close examination shows that the first sets of lines have been displaced along the second sets by a minute amount, so that they no longer register exactly.

The nature of these lines has been very carefully investigated,[5] and they are known to represent block movement or slip along crystallographic planes. The lines observed are steps on the polished surface produced by the elevation or depression of blocks or fragments of the grains. They are called *slip bands* and the crystallographic planes along which slip occurs are called *slip planes*. A slip band becomes visible under the microscope only when the displacement along the slip plane is on the order of 0.00001 in., which corresponds roughly to 1,000 atom diameters. Displacements have been measured as high as 0.00005 in., or about 5,000 atom diameters. Even greater movements probably occur in severe deformation.

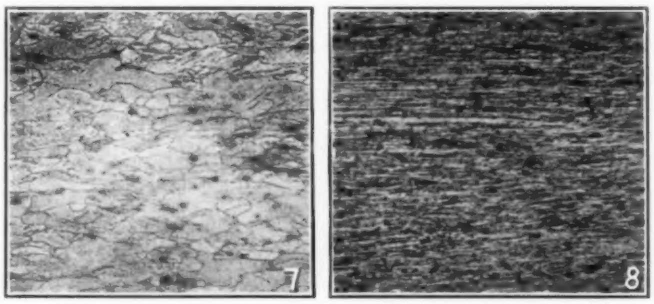
Cold-Work or Plastic Deformation

The great permanent deformations imposed on metals in the various processes of mechanical working, such as rolling, forging and drawing, are substantially integrations of very many block movements along slip planes. This type of deformation is called plastic deformation, as opposed to fluid deformation, which is characteristic of liquids and of amorphous solids like pitch and glass. In plastic deformation relative motion is confined to the slip planes, the crystalline fragments between such planes moving as units in which the atoms retain substantially their initial relative positions with respect to their neighbors.

When the external shape of a piece of metal is changed by a deforming load, the shapes of the grains undergo similar changes. Normally, the grains are so shaped that on the average their diameters are equal in all directions. Such grains are called equiaxed grains. Now if the metal is deformed as by drawing out into a wire, the grains are similarly drawn out. The change in the external shape of a grain is made up of a multitude of minute slips each so small that the grain retains an apparently smooth outline. In Fig. 7 is shown a section through the piece of iron shown in Figs. 4 and 5, after compressing it cold until its height was reduced about 60 per cent. A much greater degree of deformation is represented in Fig. 8, a section through a piece of drawn tungsten wire. The specimen shown in Fig. 7 was repolished and etched after being compressed, a procedure which effaces slip bands. However, lines are visible within the grains which are undoubtedly due to the cold deformation. Rosenhain considers these to be the traces of slip planes on the plane of the microsection. Howe is less certain of their nature, and calls them "X-bands."

Grain deformations are permanent when effected below a temperature known as the annealing temperature or recrystallization temperature. If the metal is subsequently heated above that temperature, the grains recrystallize into new grains which have a tendency toward equiaxial shape and bear little relation to the old grains. If the deformation is carried out above the annealing temperature, the mechanism is substantially the same, except that the metal anneals during the working. Mechanical work carried out on a metal above the annealing temperature is called hot-working, while if the temperature is below the annealing temperature it is called cold-working. Cold-work results in a distorted structure and increased hardness. Hot-working produces a normal structure without any hardening. Cold-working followed by annealing has similar effects to hot-working.

When a ductile or malleable crystal (or grain) is loaded sufficiently to cause failure along some crystallographic plane, the fragments formed cohere, and deformation takes place without rupture. The atoms of one fragment are not sufficiently removed from those of the others to lose cohesion permanently. When a brittle crystal is broken, fracture takes place usually along the crystallographic cleavage planes, and the fragments formed do not stick together. A crystal that is brittle



FIGS. 7 AND 8

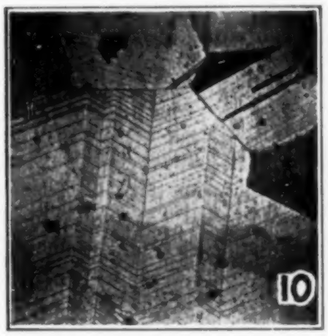
Fig. 7. Armco iron, cold-rolled, 60 per cent reduction. Compare Fig. 4. × 40.

Fig. 8. Extreme deformation of crystalline grain in tungsten wire reduced 98.8 per cent by swaging. × 160.

at one temperature may be ductile at a higher temperature. Crystals that are brittle under ordinary conditions of loading may be capable of undergoing plastic deformation under increased hydrostatic pressure. Bismuth and antimony, for example, which are ordinarily quite brittle, can be extruded into wires when sufficient pressure is applied in such a way that the metal is confined on all sides. Increase of pressure brings the atoms into closer contact, facilitating the re-establishment of cohesion bonds along the planes of failure. Increase of temperature serves the same purpose by increasing the amplitude of atomic vibrations.

Brittle metals, such as chromium and manganese, break without permanent deformation, and their cleavage planes are clearly revealed. The fracture then looks crystalline. Ductile metals break only after the grains are greatly drawn out and slip has taken place on very many planes. The fracture then has a more or less fibrous appearance which does not suggest the inherent crystalline nature of the metal. The same piece of metal, however, when subjected to repeated applications of stress, breaks along the crystallographic planes with practically no permanent deformation, and the fracture may appear crystalline. It is often said that the fatigue has caused the metal to "crystallize," whereas in reality the peculiar manner of failure has merely revealed the crystalline structure already present.

[5] "The Metallography of Steel and Cast Iron," by Henry Marion Howe; McGraw-Hill Book Co. Ewing and Rosenhain, "The Crystalline Structure of Metals," *Phil. Trans.*, vol. 195, p. 279. Stead, "The Crystalline Structure of Iron and Steel," *J. Iron and Steel Inst.*, 1898I, p. 145. "Introduction to the Study of Physical Metallurgy," by Walter Rosenhain; D. Van Nostrand Co.

FIGS. 9 AND 10

Fig. 9. Twins in alpha brass (Bassett). × 50.

Fig. 10. Slip bands in alpha brass twins (C. H. Mathewson). × 200.

Twinned Crystals

Sometimes grains grow together in such a manner that they are symmetrical structurally with respect to a plane between them. These are called twin crystals. Usually the twinning is of such a nature that if either part of the twin were revolved a certain amount about an axis perpendicular to the twinning plane the two parts would possess the same orientation and would merge. Sometimes several parallel twinning planes occur so that each alternate crystalline strip has the same orientation. This is called polysynthetic twinning. Fig. 9 shows this type of twinning in alpha brass, a solid solution possessing the essential structural characteristics of pure metal. Fig. 10 shows slip bands in alpha brass twins. It will be noted that these slip bands are continuous through each grain, but change direction at each twinning plane.

These twins in brass were produced on annealing after cold-working. Twins produced in this way are generally called *annealing twins*, to distinguish them from mechanical twins, which are formed in some metals, notably alpha iron and zinc, by cold deformation alone. Mechanical twins, in fact, are removed by annealing. Mechanical twins appearing in iron as narrow dark bands are known as Neumann bands or Neumann lines. They are parallel to certain crystallographic planes.

X-Ray Analysis of Opaque Crystals

Our study of the structure of metals is limited by the wave length of the light we use. With the highest powered microscopes available it is possible to distinguish separate particles whose diameters are not less than about one one-hundred thousandth of an inch. It is theoretically possible approximately to double this resolving power by using ultra-violet light of short wave length, but this has not so far been accomplished in a practical manner. At the best, visibility or photography is limited to distances on the order of 1,000 atom diameters.

Within the past decade methods of crystal analysis by means of X-rays have been developed by Laue, Bragg and Bragg,[6] Hull[7] and others, which extend the field of investigation down to the atom itself. X-rays are entirely similar to visible light but have wave lengths of the same order of magnitude as the distances between atoms in crystals. It has been possible by their use to determine not only the arrangements of the atoms in metals but the exact distances between them.

[6] "X-Rays and Crystal Structure," by W. H. Bragg and W. L. Bragg; G. Bell and Sons.

[7] "A New Method of X-Ray Crystal Analysis," *Phys. Rev.*, vol. 10, No. 6, December, 1917.

The fundamental principle of these methods is similar to that of the ordinary diffraction grating, which consists of a piece of glass or metal on which are ruled a great many parallel and equidistant lines. A beam of monochromatic light falling upon such a grating is diffracted through an angle depending on the wave length of the light and the spacing of the lines on the grating. When white light falls upon the grating, the rays of different wave lengths (or color) are diffracted through different angles, thus forming a spectrum. The grating can be used for the analysis of light and for the exact measurement of the wave length of any particular portion of the spectrum. Or, conversely, monochromatic light of known wave length may be used to determine the spacing of the lines on an unknown grating.

The wave lengths of X-rays are about one ten-thousandth as large as those of visible light, and it would be entirely impossible to construct a grating of appropriate spacings by the usual method of ruling lines. It occurred to Laue that the ordered arrangements of the atoms or molecules in crystals might be used for the investigation of X-rays, since the spacings of the planes of atoms (or molecules) are of the right order of magnitude. This idea has been successfully developed experimentally. The first problem was to verify the supposition that X-rays were indeed of undulatory character like ordinary light, and to measure their wave lengths. The process could then be reversed, using monochromatic X-rays of known wave length to measure the spacing of the planes of atoms in a crystal.

The problem differs from that of the ordinary grating in that the crystal grating extends over three

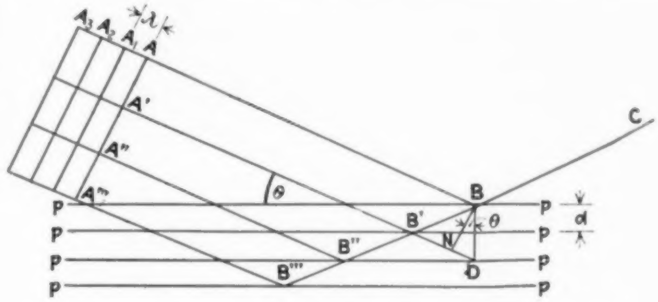


FIG. 11. REFLECTION OF X-RAYS BY ATOMS (BRAGG)

dimensions. The principle[8] can be explained by reference to Fig. 11. The lines p, p, p, etc., represent planes of atoms in a crystal, separated by a common distance d. A, A_1, A_2, A_3, etc., are a train of advancing waves of X-rays of wave length lambda (λ). Consider that these rays are partly reflected from each plane according to the usual law that the angle of incidence is equal to the angle of reflection. Only a small part is reflected at each plane, the remainder penetrating deeper into the crystal.

Consider any path of reflection as BC, which is parallel to all other paths of reflection and typical of them. The waves AB, $A'B'$, $A''B''$, etc., join in reflection along BC. These waves are in phase with one another at $AA'A''A'''$, a line perpendicular to the direction of propagation. If they remain in phase with one another after reflection along BC, reinforcement will take place and a strong beam will result. If they are not in phase, the rays will be lost by interference. The necessary condition for reinforcement is that the

[8] "Roentgen Rays and Crystal Structure," Metallurgical & Chemical Engineering, vol. 15, p. 35 (July 1, 1916).

difference in the paths of these waves must be an integral multiple of the wave length.[6] Let us express this condition mathematically:

Draw BN perpendicular to AB. Draw BD perpendicular to pp. Prolong $A'B'$ to D. Then:

$$A'B'C' - ABC = (A'D + BC) - (A'N + BC)$$
$$= A'D - A'N = DN$$
$$DN = 2d \sin\theta$$

Therefore

$$n\lambda = 2d \sin\theta \qquad (1)$$

where n is any whole number.

This is the fundamental equation. It expresses the fact that in order for strong reflection to occur, the glancing angle θ must have one of certain definite values. These values are given by:

$$\lambda = 2d \sin\theta_1$$
$$2\lambda = 2d \sin\theta_2$$
$$3\lambda = 2d \sin\theta_3, \text{ etc.}$$

The reflection at the angle θ_1 is called the reflection of the first order, that at the angle θ_2 reflection of the second order, and so on. The possible number of reflections is limited for given values of d and λ, since $\sin\theta$ cannot have a value greater than 1.

Then in the limit:

$$n\lambda = 2d$$
$$n = \frac{2d}{\lambda} \qquad (2)$$

For example, if the spacing, atom to atom, equals 5×10^{-8} cm., and the wave length in use is 3.5×10^{-8} cm., $n = \dfrac{2 \times 5 \times 10^{-8}}{3.5 \times 10^{-8}} = 2.85$. Reflections of the first and second order only are possible.

Now let us represent an experimental set-up by the line drawing of Fig. 12.

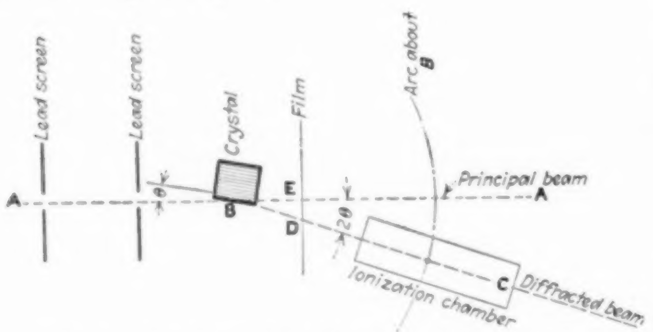


FIG. 12. DIAGRAM OF APPARATUS FOR CRYSTAL ANALYSIS

A-A is a pencil of monochromatic X-rays. B is a crystal having crystallographic planes (planes of atoms) as indicated by the fine parallel lines. B is mounted on a pedestal capable of rotation about an axis perpendicular to the plane of the paper.

C is a device for detecting X-rays, such as an ionization chamber. (X-rays have the property of ionizing gases, thereby causing them to conduct electricity. The conductivity of the gas in the chamber C can be measured by means of an electroscope, which gives a measure of the intensity of X-radiation entering C.) C is mounted to swing on the arc indicated about the same axis as B. By rotating B on its axis and C along its arc, several conjugate positions can be found for which strong reflections will enter C, corresponding to the various orders of reflection. The angles θ_1, θ_2, etc., can readily be measured and, given the wave length of the radiation, the spacing of the planes of atoms can be calculated in accordance with the equation (1).

By choosing different faces of the crystal, this process can be repeated so as to give the spacings of the various sets of parallel planes, from which data the arrangement of the points in the space lattice can be deduced.

Hull's Method of Crystal Analysis

Suppose that the crystal B in Fig. 12 is properly oriented for a reflection of the first order. If a photographic film DE is interposed perpendicular to the beam AB, the diffracted beam will strike it at the point D, on the path of BC. The principal beam AB will for the most part not be diffracted, and will strike the film at E. Now suppose the crystal to be so mounted that it can be rotated about A-A as an axis; during the rotation, the correct glancing angle θ_1 will be preserved, and the diffracted beam BDC will draw on the film a circle about E as a center. One complete rotation of the crystal will cause it to assume successively *all* of the positions from which it is capable of sending out a reflection of the first order from the particular set of planes in question. The diffracted beam generates a cone of light about A-A as an axis. A film interposed cuts out a circle, which is thus the locus of all the possible first-order reflections from this set of planes.

For reflections of higher orders, other circles will be drawn on the film, having diameters increasing with the order of the reflection. It will of course be necessary to reset the crystal to the proper glancing angle in each case before carrying out the rotation about A-A.

Now suppose the crystal to have its orientation so altered that another set of crystallographic planes diffracts beams on to the film. If we repeat the above process of setting the crystal to the proper glancing angles and rotating it about A-A, we will obtain another set of circles representing the various orders of reflection. If the spacing of the planes differs from that of the first set, the circles will have different diameters, corresponding to the different glancing angles involved.

This process might be repeated for every set of crystallographic planes. The result would be a series of concentric circles. Each circle would be proof of the presence of a set of planes having that particular spacing capable of diffracting a beam through the angle represented by the circle.

Instead of carrying out this process by the systematic method of setting the crystal and rotating it about A-A, we might simply cause the crystal to assume successively all possible orientations. We would then get exactly the same pattern of concentric circles. Or, if instead of a single crystal, we choose as our specimen a very large number of small crystals, of thoroughly mixed orientation, we obtain again the same result, without rotating the specimen.

This is the foundation of Hull's generalized method of crystal analysis, or the method of powders.[7] A fine grained metal possesses the same properties as a powder for this purpose, since it is an aggregate of crystalline grains of mixed orientation. Smaller specimens can be used if they are rotated, as this gives the effect of a greater number of crystal orientations. A single photograph of such a specimen gives all of the possible circles and hence the spacings of all pos-

sible crystallographic planes. A diffraction pattern of aluminum obtained by this method is shown in Fig. 13. In actual practice it is customary to photograph only one quadrant of the pattern, and to bend the film into the arc of a circle so that the distances between the lines cut from the large circles are proportional to the angles involved. Patterns of this type are shown in Figs. 14 and 15. Fig. 14, in fact, may be considered a magnified section of a portion of Fig. 13. It was photographed on a film bent around an arc about *B*, whereas Fig. 13 was a flat plate; consequently the ratios of the distances between successive lines do not have a simple arithmetical relation. However, two bright lines are followed by a broad space, a bright line, a narrow space, two close lines, one brighter than the other, etc.

Atomic Arrangement

In this discussion we have necessarily been obliged to omit consideration of many important details, in order to simplify the presentation of the essential principles. It is also beyond the scope of this article to go into the actual synthesis of crystal structures from the data obtained by these methods, subjects which are completely discussed in the appended references. For the present we shall confine ourselves to the presentation and discussion of some of the results thus far obtained on metals. The arrangement of atoms in metals has been found to be extremely simple.

The most simple arrangement possible is one in which the atoms occupy positions at the corners of a system of equal closely packed cubes. This is known as the simple cubic arrangement. No metals or other elementary substances have been found to have this arrangement, but it is typical of salts composed of equal numbers of positive and negative ions, such as the alkali halides. The most common arrangement in metals is the face-centered cubic arrangement, shown in Fig. 16, where the atoms are at the corners of a system of equal closely packed cubes and also at the centers of each cube face. This arrangement may be considered as formed by two simple cubic lattices intersecting each other in such a manner that the corner atoms of one lattice fall at the centers of the faces of the other lattice. All of the atoms in the face-centered arrangement are in reality similarly situated. Any particular set of atoms may be equally well regarded as corner atoms or as face atoms. Each atom is surrounded by twelve equidistant and symmetrically situated atoms. This arrangement is one of two which furnish the closest possible packing for a number of equal balls. It is accordingly sometimes referred to as the cubic close-packed arrangement.

The next most common arrangement is built upon a unit cube having an atom at each corner and one at the center. This is illustrated in Fig. 17. The corner atoms and center atoms are interchangeable, so that if the system of lines in Fig. 17 had started with one of the center atoms all the corner atoms would become center atoms, and *vice versa*. Each atom is surrounded

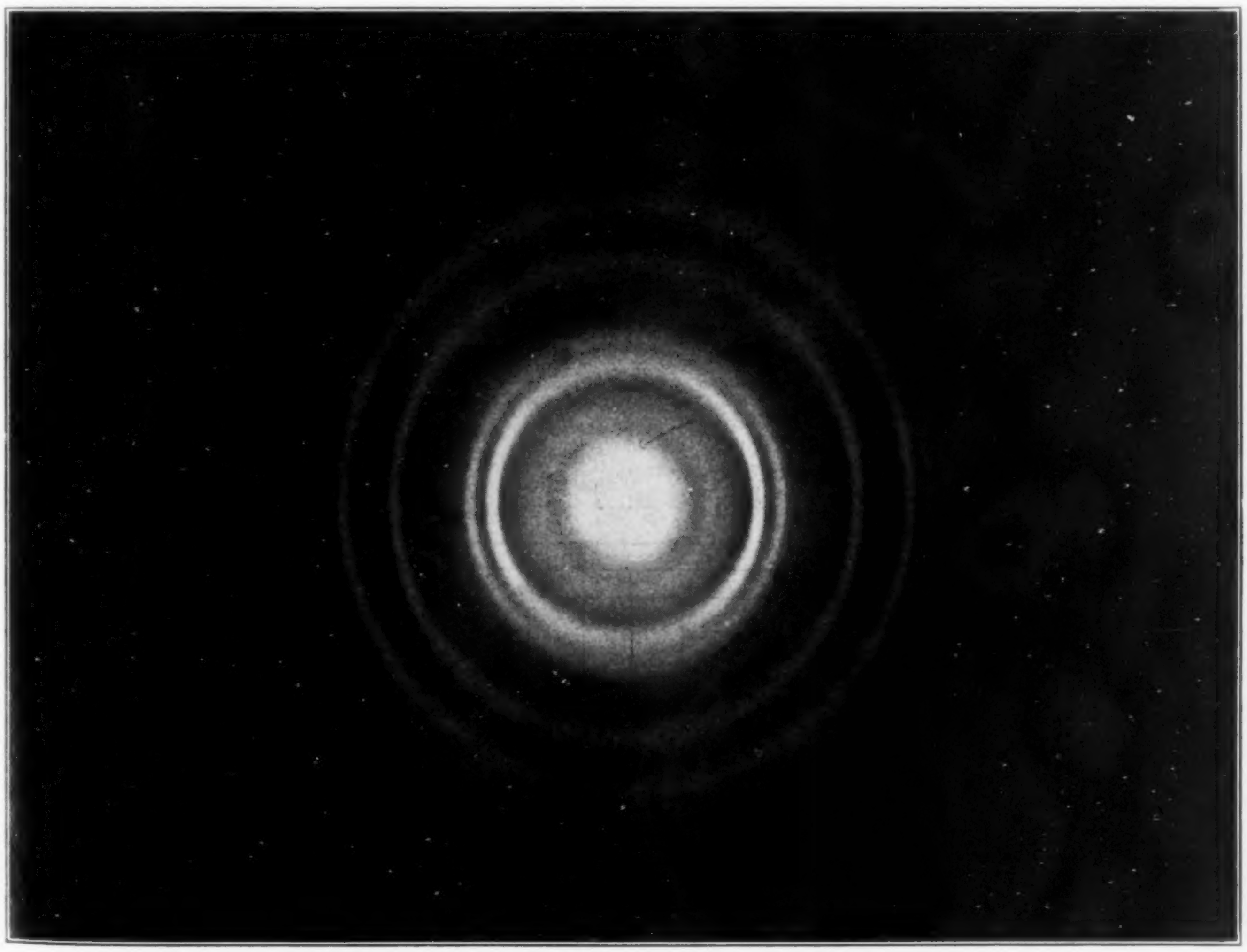


FIG. 13. DIFFRACTION PATTERN OF ALUMINUM (HULL)

by eight equally distant and symmetrically situated atoms. This arrangement is not so closely packed as the face-centered arrangement.

There is one other arrangement found in metals, known as the hexagonal close-packed arrangement (Fig. 18). It is equally close packed with the face-centered cubic. The space occupied by a crystal of this sort may be regarded as built up of a series of equal closely packed right triangular prisms whose bases are equilateral triangles. The altitudes of the prisms are equal to 1.633 times the length of the sides of the triangles. An atom is located at each prism corner and at alternate prism centers. Each atom is therefore surrounded by twelve other equidistant atoms, as in the face-centered cubic arrangement, but not quite so symmetrically.

The following table by Hull[9] gives information on the positions of atoms in several metals. (1 Angstrom is 0.00000001 cm. = 10^{-8} cm.):

Metal	Arrangement of Atoms	Length of Side of Elementary Cube in Angstroms	Distance Between Centers of Nearest Atoms in Angstroms
Aluminum	Face-centered cubic	4.05	2.86
Cobalt [10]	Face-centered cubic	3.57	2.52
Nickel	Face-centered cubic	3.54	2.50
Copper	Face-centered cubic	3.60	2.54
Rhodium	Face-centered cubic	3.82	2.70
Silver	Face-centered cubic	4.06	2.87
Platinum	Face-centered cubic	4.02	2.85
Gold	Face-centered cubic	4.08	2.88
Lead	Face-centered cubic	4.92	3.48
Lithium	Centered cubic	3.50	3.03
Sodium	Centered cubic	4.30	3.72
Chromium	Centered cubic	2.91	2.52
Iron	Centered cubic	2.86	2.48
Molybdenum	Centered cubic	3.15	2.73
Tungsten	Centered cubic	3.15	2.73
Magnesium	Hexagonal (close packed)	....	3.22
Zinc	Hexagonal (close packed)	....	2.84
Cadmium	Hexagonal (close packed)	....	3.15
Cobalt [10]	Hexagonal (close packed)	....	2.53

[9] "The Position of Atoms in Metals," American Institute of Electrical Engineers, 1919.

[10] The case of cobalt is exceptional in that both the hexagonal and cubic close-packed arrangements are found.

The study of the positions of atoms in metals is so recent that only a few generalities can be drawn at present. Some features which may be mentioned are:

1. No metal crystallizing with the face-centered cubic arrangement has been found so far which is not ductile throughout a considerable range of temperature. The face-centered metals are usually ductile even at liquid air temperatures.

2. All of the noble metals so far studied crystallize with the face-centered cubic arrangement.

3. All of the best electrical and heat conductors have face-centered cubic arrangements.

4. Both ductile and brittle metals are found in the body-centered cubic arrangement. This system seems to be less favorable to ductility than the face-centered, according to Hull.

5. In the hexagonal arrangement both brittle and ductile metals are found. In ductile hexagonal metals the temperature range in which ductility obtains is relatively small. Hull points out that in the hexagonal arrangement there is only one set of planes parallel to which easy gliding can take place, whereas in the face-centered cubic there are four.

6. Metals having the hexagonal close-packed arrangement harden rapidly under cold deformation.

7. Mechanical twinning (Neumann lines) occurs in metals having the centered cubic and the hexagonal close-packed arrangements. Alpha iron is an example of the former and zinc of the latter. Mechanical twins have also been observed in tin, which is thought to crystallize in the tetragonal system.

8. Annealing twins are certainly most prevalent in metals crystallizing in the face-centered cubic arrangement.

9. Annealing twins have not been observed in metals

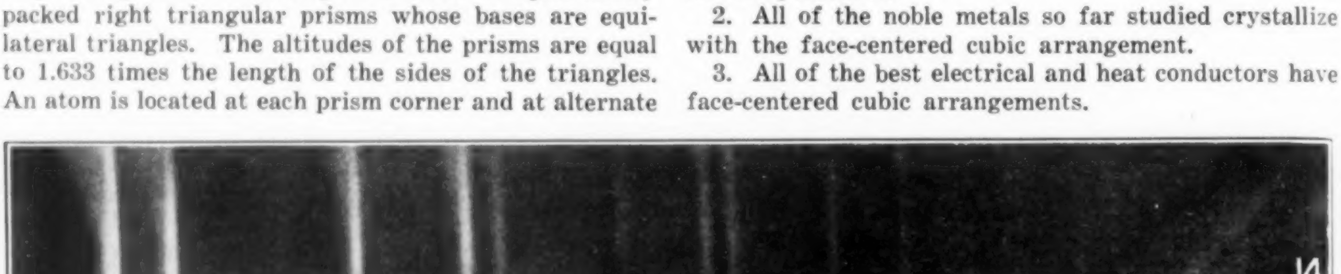


FIG. 14. DIFFRACTION PATTERN OF ALUMINUM, PHOTOGRAPHED ON CURVED FILM (HULL)
FIG. 15. DIFFRACTION PATTERN OF MOLYBDENUM (HULL)

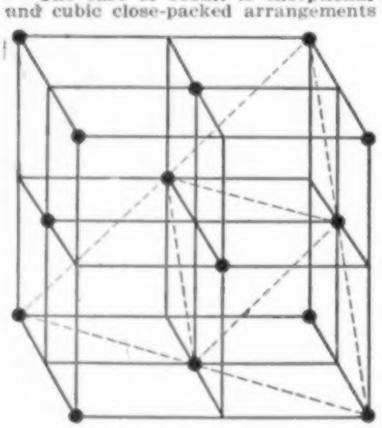


FIG. 16

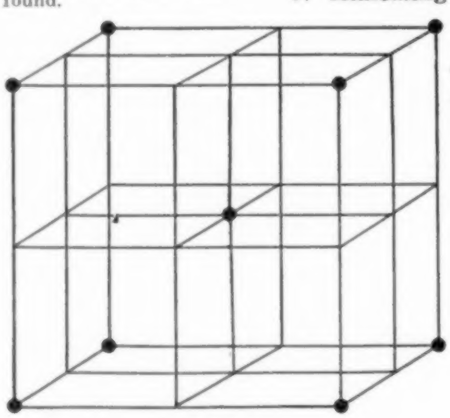


FIG. 17

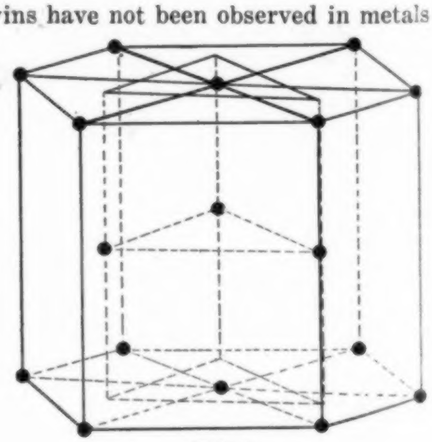


FIG. 18

FIGS. 16, 17 AND 18

Fig. 16. Face centered cubic arrangement of atoms; or cubic close packing (Hull).

Fig. 17. Centered cubic arrangement (Hull).

Fig. 18. Hexagonal close-packed arrangement (Hull).

having the centered-cubic arrangement, such as alpha iron, tungsten and molybdenum.

10. Not all face-centered metals show twinning. Twin crystals have not been observed in aluminum, for example.

Allotropy

Several of the metals are known to exist in two or more allotropic modifications. The most important case is that of iron. Steel owes its remarkable capacity for hardening to the fact that at high temperatures iron exists in the form of gamma iron having a very considerable solvent power for carbon, while alpha iron, the form stable at ordinary temperatures, has in comparison no such solvent power.

It has been difficult to define allotropy in a certain manner. The new information on crystal structure suggests that an allotropic change may be defined as a change in atomic arrangement. This definition should furnish a positive criterion of allotropy, hindered only by the experimental difficulties involved in determining atomic arrangements at high temperatures.

The gamma form of pure iron is stable only above 900 deg. C., and its atomic arrangement has never been determined. It is possible, however, by means of certain alloying elements to preserve at room temperatures solid solutions, denoted by the generic term austenite, which are isomorphous with gamma iron. Such an austenitic steel is obtained, for example, by the use of about 13 per cent manganese. This material has been examined by Jeffries and Bain and found to possess the face-centered cubic arrangement, which may therefore be assumed to be the arrangement in gamma iron. In common with other metals having this arrangement of atoms, austenitic steels are very ductile, and also show twinning. The fact that the face-centered cubic arrangement is more closely packed than the centered cubic arrangement accords nicely with the expansion noted when gamma iron transforms into non-gamma.

The arrangement of atoms in several solid solution alloys has been investigated by Hull, Davies and Andrews of the General Electric Co. It seems that the atoms of the solute generally replace those of the solvent without substantial change in the arrangement or spacing. If two metals have different crystalline arrangements there may be a certain range of composition within which both arrangements are found simultaneously.

Although intermetallic compounds have not been studied with the X-ray, it seems obvious that in the crystal lattice the atoms of the different elements are not interchangeable, as they appear to be in solid solutions.

The information to be yielded by the X-ray analysis of metals has only begun to accumulate. We may confidently expect further important results in the future, concerning in particular the constitution of metallic solid solutions and of intermetallic compounds. The methods should also enable us to detect the presence of a second physical phase in a metal, such as a highly dispersed intermetallic compound, when the particles of this phase are too fine for resolution by the microscope. Altogether, the advent of the X-ray spectrometer at the present time promises to be about as important an event in the history of metallurgy as was the introduction of the microscope in the latter part of the last century.

Supply of Potash in Illinois Shale

The discovery of shale in Illinois which may prove a cheap American source of potassium for agricultural purposes, and which is rich enough in potassium to increase the yield of certain crops grown on peaty soil as much as 180 per cent, is announced by the University of Illinois. Tests have been in progress since 1915 to find a source of potassium.

The experiments carried on under greenhouse control indicate marked benefit to crops resulting from applications of the shale. The shale produced an increase in the yield of sweet clover of 168 per cent; of rape, 96 per cent; of corn fodder, 146 per cent, and of buckwheat, 180 per cent. These results were obtained on peaty soil in pot-culture work.

There is also some indication, according to the university, that the shale may serve as a source of potassium for gray silt loam, another type of Illinois soil. In the production of buckwheat, there was an increase from use of shale of 32 per cent in the grain and 19 per cent in the straw. Corn fodder also showed increases.

Shales which contain 5 per cent or more of potash occur in at least two localities in Illinois. Outcropping in several places near Jonesboro, in Union County, which contains 5 per cent of potash would be suitable, so far as can be determined from its chemical composition and physical character, for use in the manufacture of portland cement. By using this material in the manufacture of cement and by applying the known methods of potash recovery, a yield of 5.3 lb. of potash, representing a value of 70c. to 80c. per barrel of cement, could be obtained. Shale from Dixon, Lee County, contains 5.8 per cent of potash, which is held for the most part in a more stable condition than that in the southern Illinois shale.

While further experimentation will be necessary to determine whether these potassium compounds can be made available under field conditions, enough has been done to show not only the presence of vast amounts of this valuable material in Illinois shales, but also to demonstrate that the compounds are capable of reduction by agricultural plants grown under laboratory conditions.

Agricultural Experiment Station Bulletin 232 just off the press at the University of Illinois, Urbana, Ill., describes in detail the research carried on by S. W. Parr and M. M. Austin in the chemical laboratory. Part II of the same bulletin covers the geology of the subject investigated by Frank Krey. Part III covers the work of Robert Stewart, chief in soil fertility at the university, who determined the action of these shales in soil improvement for growing plants.

Chemical Tonnage on Class 1 Railroads

In analyzing the freight tonnage handled by the Class 1 railroads during the last quarter of 1920, the Interstate Commerce Commission finds that chemicals and explosives furnished 1,987,141 tons of freight. Fertilizers are shown separately and account for 981,935 tons more.

By far the greater part of the chemical and explosives tonnage of the country is handled by the railroads in the Eastern district, where the amount is shown to have been 1,286,457 tons. The Western district was in second place with 352,186 tons, while the railroads of the Southern district handled 257,309 tons.

A Device for Measuring the Flow of Gases

By Carle R. Hayward*

DURING some tests in the metallurgical laboratory of the Massachusetts Institute of Technology it became necessary to measure the flow of gas from a cylinder of liquid SO_2. The nature of the gas prevented the use of an ordinary meter and the amount was so small that the change in weight of the cylinder was not

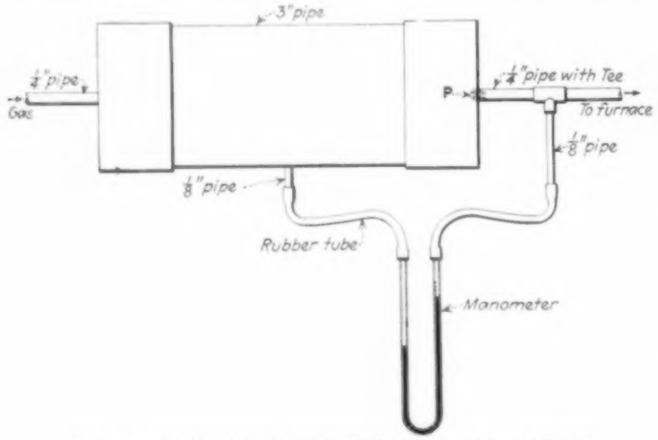


FIG. 1. PRESSURE DIFFERENTIAL GAS METER

easily measured. It was also desirable to change the rate of flow at will.

The apparatus devised for the above purpose is shown in the sketch (Fig. 1). The fundamental principle is well known, but some features of construction are believed to be new. The device is easily made and is so useful that a brief description may be of interest.

The body consists of a piece of ordinary 3-in. steel pipe, 8 in. long capped at both ends. A hole is bored in each cap and threaded to receive short lengths of ¼-in. pipe as shown. The pipe from one cap is fitted with a T into which is put a short piece of ⅛-in. pipe. The side of the 3-in. pipe is also bored to receive a piece of ⅛-in. pipe. Each of the ⅛-in. pipes is connected to one arm of a U manometer which may contain either mercury or water according to pressure used. The gas flows in the direction indicated by the arrows.

The pipe leading out of the pressure chamber is threaded to receive a brass plug *P*, through which a small hole is bored. A series of these plugs is kept on hand with holes varying in size from 1/64 in. to ⅛ in. The plugs can be easily changed by removing the cap from the large pipe. For very small flows a piece of broken thermometer tube has been cemented in the pipe in place of the plug.

The operation of the meter is self-evident from a study of the sketch. The flow of gas through the orifice in the plug *P* depends on the size of the orifice and the difference in pressure on the two sides of the plug. The latter is measured by the manometer. Precautions must be taken to have all joints tight.

The flow through each plug was determined for different manometer readings by connecting the meter to a compressed air line and measuring the flow with a gas meter, or in the case of very small volumes by displacing water in a graduated tube. Having determined the flow for each inch difference in pressure, the results are plotted in a curve. The general shape of these calibration curves is shown in Figs. 2 and 3.

After determining the curve for each plug the meter is available for use on any gas. The writer has used it for SO_2, hydrogen and air in volumes varying from 3 liters per hour to 100 liters per minute. Pressures have varied from 1 in. of water to 30 in. of mercury.

It is possible to use the meter with the gas flowing in the direction opposite to that shown in the sketch, but the adjustment when used in that way does not seem so sensitive under the high gas pressures thus far used. It is possible that with low initial gas pressures it would be more satisfactory.

The original suggestion for using pipe fittings for this device was made by Henry M. Schleicher, to whom credit is gladly given.

*Assistant Professor of Metallurgy, Massachusetts Institute of Technology.

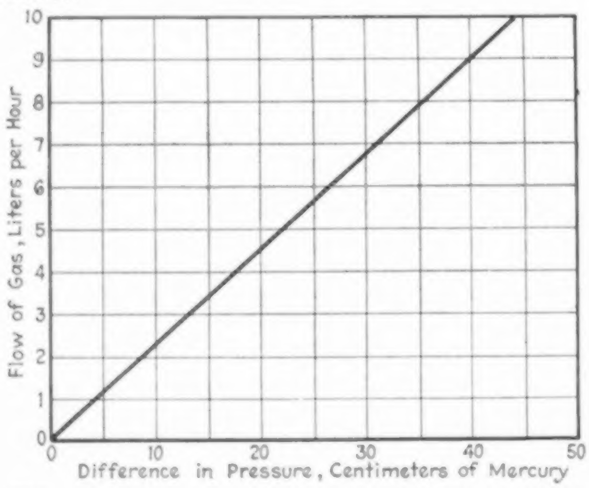


FIG. 2. CURVE WHEN CAPILLARY TUBE IS USED

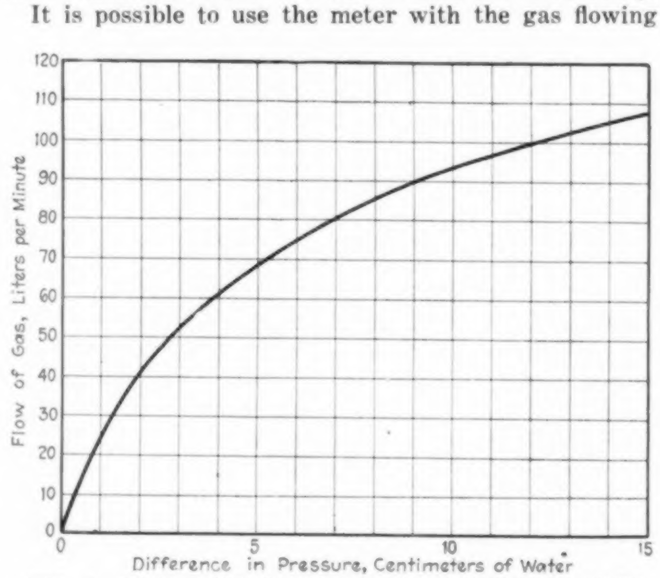


FIG. 3. CURVE WHEN NO CAPILLARY TUBE IS USED

Municipal Sulphuric Acid Plant Proposed

It is reported that there is under consideration the building of a sulphuric acid plant by Bradford in connection with the city's sewage works, reports Consul Young, of Bradford, England. This plant uses large quantities of sulphuric acid for precipitation purposes.

Before the war the sewage department paid 25s. ($6.08) a ton for the acid. At the present time the cost is about £6 ($29.20). At this latter figure it is estimated that £100,000 ($486,650) for sulphuric acid will be needed annually, and it is believed that if the sewage committee built its own works the acid could be produced at less than half the present cost.

Present Status of Fruit and Vegetable Dehydration

Results of Investigation and Fundamental Principles of Operation and Construction of Fruit and Vegetable Dehydrating Plants—Advantages of Dehydration—Data on Air Volume, Thermal Units and Humidities Required

BY WILLIAM V. CRUESS
Assistant Professor of Fruit Products, University of California

AS A result of the stimulus of government orders for dehydrated vegetables for army use during the World War many firms in different parts of the United States and Canada undertook the large-scale production of Julienne (vegetable soup mixture), dehydrated potatoes, onions, carrots, spinach and other vegetables. A few of these manufacturers had previous experience in dehydration, but to most of them the industry was new. With assistance from officers of the quartermasters corps, investigators of the U. S. Department of Agriculture and state experiment stations most of these new plants were soon placed upon a satisfactory producing basis. Considering the many difficulties to be met in vegetable dehydration, the rapid rate of progress made by those who undertook to supply the army with dehydrated products is truly remarkable.

The success obtained in producing dehydrated vegetables for the army led a number of firms immediately after the close of the war to attempt the dehydration and sale of dehydrated fruits and vegetables for civilian use. To create a demand they relied upon the high quality of their product, its cheapness and convenience. Some of the pamphlets issued by newly organized dehydration companies painted a most rosy future for the dehydration industry and promised large and quick returns to those who should invest in the new enterprise.

Evidently these overoptimistic promoters were "ahead of the times," because most of them have fallen by the wayside and nothing remains of their ill-fated projects except unpaid bills and idle evaporators.

There are, however, several very well-financed corporations managed by men who not only know the many advantages of dehydrated foods but who also realize the need of popularizing such foods and of educating the housewife, through advertising, to change her age-old custom of using fresh vegetables only when she can get them and doing without when fresh vegetables are not in season.

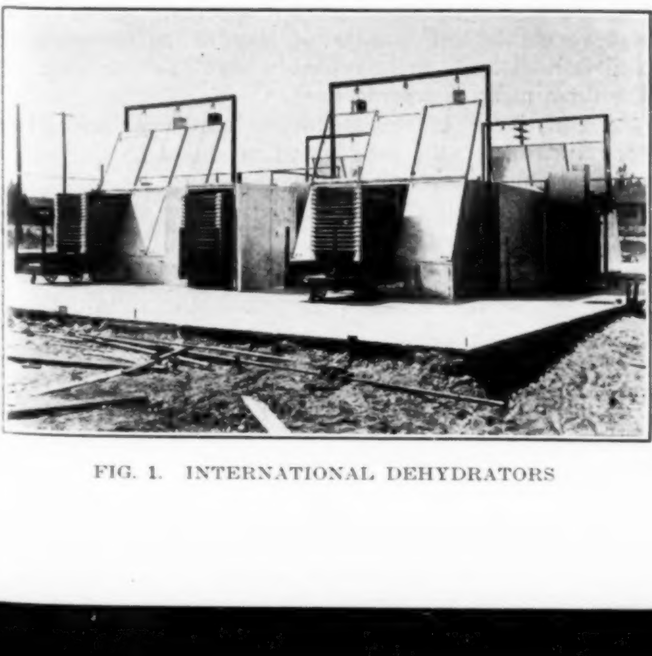


FIG. 1. INTERNATIONAL DEHYDRATORS

There has also been another condition to blame for the present slump in dehydration. A considerable amount of inferior dehydrated vegetables has been produced and has created an unfavorable impression upon those who have purchased it. Through carelessness or lack of technical knowledge on the part of some manufacturers, dehydrated products have developed lusty infestations of the Indian meal moth (*Plodia interpunctella*) after leaving the factory. Both of these conditions have now to a very great degree been removed; the first by virtue of the fact that most of the inexperienced operators of dehydrators are bankrupt and the second because the manufacturers now know how to prevent insect infestation.

COMMERCIAL OPERATIONS

At the present time one corporation in Oregon, the Kings Food Products Co., is operating two large plants representing an investment of over half a million dollars. Dehydrated fruits are the principal products. These find a ready market at prices considerably above those paid for the average "run" of evaporated fruits and the profits from these fruits in a large measure "pay the way" for the development and advertising of the dehydrated vegetables produced by this same company. Over $500,000 has been spent by this one firm in national and local advertising. Its owners state that they would welcome competition from other concerns which would produce dehydrated vegetables and fruits of the highest quality in order that the popularization of dehydrated foods might be hastened. This firm has recently been capitalized for $10,000,000 and will establish new plants in addition to expanding the two now in operation.

In California a large plant has been built and is operated by the Caladero Products Co., a subsidiary of the Atascadero Colony. It represents an investment of over $200,000 and has been one of the most successful of the large dehydrators on the Pacific Coast. The products are advertised through the columns of the colony's monthly illustrated *Review*, a journal with a wide circulation. The company is now specializing upon pumpkin flour, which is ground dehydrated pumpkin put up in canisters for the preparation of pumpkin pies. The product is excellent in flavor and color and very convenient to use. It has met with great favor and gives promise of becoming a staple article of trade.

The Japanese farmers of southern California have erected in Los Angeles a modern dehydrating plant equipped with modern machinery. They have made a special effort to popularize a dehydrated soup mixture. The plant is used as a means of converting surplus

vegetables in times of overproduction into marketable products. The company is known as the California Evaporated Products Co. and markets its dehydrated products under the name "Cepco."

In Chicago the Anhydrous Food Products Co. has recently launched upon a campaign of expansion, and its development is watched with great interest by those interested in dehydration on the Pacific Coast. Dehydration of sweet corn is, in the writer's estimation, by far the best of the dehydrated vegetables so far produced. Sweet corn is reported to have been dehydrated by the carload in several Eastern states during the past season.

Other companies might be mentioned, but the situation is perhaps best summarized by stating that the dehydration industry is now on a well-established basis in several states, but will require a great deal of money for advertising purposes before it becomes a major food preservation industry. Development also depends upon standardization of equipment and processes. Time and sustained effort on the part of American dehydration companies will be needed to place this industry upon the basis that the advantages of the dehydration process warrant.

In European countries the advantages of dehydration have been recognized more universally than in America. Germany possessed, it is stated by Prescott and Sweet, in 1906, 36 dehydration plants; in 1909, 199; in 1914, 488 and in 1917, about 1,900 plants. Some of these were "built-over" breweries. The amount of potatoes dried in Germany in 1917 was more than three times the total crop of the United States for that year. These facts afford one reason why Germany was able to maintain her food supply during the war.

The writer has recently seen dehydrated vegetables in compressed brick form which had been exported to the United States from Holland in commercial quantities. These were of very excellent quality.

Advantages of Dehydration

It is stated that 20 to 40 per cent of all fresh fruits and vegetables spoil between the producer and the consumer. Dehydration offers an economical and thoroughly satisfactory means of converting such surplus into non-perishable products. As the population of the world increases and the struggle for existence becomes more keen, dehydration may well serve to increase the available food supply by reducing waste through spoiling of fresh products. It can serve to stabilize production and markets by making it possible to store one year's overproduction for use in a year of underproduction.

One of the most evident advantages of dehydrated foods is their small bulk and weight. Many vegetables lose 80 to 95 per cent of their weight in drying and decrease to from one-quarter to one-half their original volume. By compression into bricks the volume can be decreased in some cases to one-tenth or less the original volume of the fresh material. The small bulk and weight of dehydrated foods effect a saving in transportation and storage costs.

If properly disinfected or sterilized to destroy insects and packed in insect-proof containers, dehydrated foods will keep for very long periods of time. The writer has recently used dried soup vegetables said to have been dehydrated fifteen years ago. Vegetables dehydrated for use of the British Army in South Africa were in one instance stored in paraffine-sealed barrels at the end of the Boer War. At the outbreak of the European war, fifteen years later, these barrels were opened, the contents found good and the vegetables used by the British forces. This instance has been reported by Prescott and Sweet.

Canned foods are much more bulky than dehydrated products and more costly to the consumer. For example, it has been stated that a case of canned tomatoes costing $2.60 in California costs $7 when delivered to Havre, France. The same quantity of tomatoes dried and selling at 26c. per lb. in California would cost, delivered in Havre, 40.5c. per lb., equivalent to $1.22 a case, since a case of tomatoes contains about 45 lb. of vegetables and tomatoes dry in the ratio of about 15 lb. of fresh to 1 lb. dry.

Table I, compiled from data published by Prescott and Sweet,[1] summarizes the relation between the weight of dried and canned products from one ton of fresh fruits and vegetables.

TABLE I. WEIGHT OF ONE TON OF VARIOUS FRUITS AND VEGETABLES CANNED AND DRIED

Material	Weight Canned and Boxed, Lb.	Weight Dried, Lb.
Corn	1,426	465
Peas	4,291	350
String beans	3,832	200
Tomatoes	1,763	125
Pumpkins	2,146	200
Sweet potatoes	2,250	513
Cabbages	2,400	215
Apples	2,640	200–300
Peaches	2,850	300–400
Apricots	2,850	300–400
Pears	2,850	400–570

Dehydrated foods are of "net food value." That is there is no waste in paring or trimming or waste in discarding sirup or brine as is the case with fresh and canned products. The usual labor involved in preparing fresh vegetables for cooking is eliminated for the housewife. All that she need do is to soak the vegetables several hours in water and they are ready for cooking.

However, the principal argument advanced by housewives against dehydrated foods is the fact that they must be soaked in water before cooking. Dehydrator operators are now attempting to develop methods of drying that will permit cooking of the dried products without preliminary soaking. Considerable progress has been made upon this problem.

Dehydration Defined

There is considerable confusion regarding the proper terminology for dried products. Manufacturers of equipment used for drying foods almost universally style their machines "dehydrators" and speak of the process as "dehydration." The producers of dried fruits and vegetables use the terms dehydration, evaporation and desiccation. It is probable that "dehydration" is the term most commonly used.

A committee[2] of representative producers, investigators and dealers in dehydrated products in California adopted the following recommendations:

1. That "drying" be considered the general term applying to all methods.
2. That "sun drying" be used to designate the drying of fruits by the sun's heat.

[1] "Commercial Dehydration: A Factor in the Solution of the International Food Problem." by S. C. Prescott and L. D. Sweet; *Annals* of the American Academy of Political and Social Science, May, 1919, No. 1294.

[2] Committee consisting of A. W. Christie, University of California; P. F. Nichols, U. S. Department of Agriculture, Division of Dehydration Investigations; F. C. Simonds of E. C. Horst Co.; E. W. Sheehan, dealer in dried fruits; H. C. Rowley, Editor *California Fruit News*.

3. That "evaporation" and "dehydration" be considered of equal value in designating the drying of foods by artificially produced heat.

Prof. S. C. Prescott, former chief of the Division of Dehydration Investigations of the U. S. Department of Agriculture, prefers to give modern dehydration a meaning somewhat different than that of evaporation. He considers that dehydration is a more carefully controlled process and results in a superior dried article to that produced by evaporation. His definition follows: "When we speak of 'modern' dehydration we mean foods which either with or without previous treatment have been subjected to the action of carefully regulated currents of air in which the temperature and humidity are both properly controlled, a process which results in the food gradually losing water, but without giving up its color or flavor or having its cellular structure injured."

The writer believes that the word dehydration will in time displace in popular favor the word evaporation, judging from the marked present tendency.

Many of the processes used in dehydration are based upon the results of empirical experiments, but there are certain underlying fundamental principles which afford a rational basis for study of the subject.

Heat Efficiency

Dehydration involves the change of water from the liquid to the vapor state. This change requires the expenditure of a definite amount of heat, which is about 965 B.t.u. per pound of water evaporated at 212 deg. F.

FIG. 2. STACK EVAPORATOR

and 1,102 B.t.u. at 60 deg. F. From 50 to 75 B.t.u. must be added for each pound of fruit to account for heating the fruit from room temperature to the temperature used in the evaporator. The fuel efficiency of an evaporator can be judged by its approach to the theoretical minimum in its use of heat. We may take this minimum as approximately 1,075 B.t.u. For field purposes A. W. Christie and the writer use the following formula for arriving at an approximate measure of the efficiency of evaporators:

$$E = \frac{F - D \times 1075}{G \times 135000}$$

In this formula

E = fuel efficiency of the evaporator.

F = pounds of fresh fruit placed in the evaporator during the test.

G = gallons of fuel oil used during the test with an assumed calorific value of 135,000 B.t.u. per gal.

D = pounds of dry fruit removed from the evaporator during the test.

Most evaporators tested show an efficiency of less than 50 per cent. An efficiency of 40 per cent is considered good. One reason for this relatively low efficiency is found in the fact that the air must be allowed to leave the evaporator from 20 to 60 deg. F. above the outside air—e.g., air will often be taken into the furnace room at 80 deg. F., then heated to 165 deg. F., used in drying and leave the evaporator at 110 deg. F. It has been raised 85 deg. F. and the air still retains unused 30 deg. F. of the original rise in temperature as it leaves the evaporator.

Many evaporator designers fail to take into account these facts and equip their plants with too small an air-heating system.

Area of Heating System

If air is to be heated by steam coils or furnace pipes the total area of the heating surface required may be arrived at by means of the following formula.[3]

$$H = \frac{Cg}{tm(2 + 10\sqrt{c})}$$

where

H = heating surface in square meters.

tm = mean difference in temperature of the surface and air.

c = velocity in meters per second.

Cg = calories per hour required.

The heating system is more efficient the greater the difference in temperature tm.

The heat transfer varies with the square root of the air velocity—that is, the coefficient of heat transmission is

$$K = 2 + 10\sqrt{c}$$

where c = velocity of the air.

The area of the heating system must be large enough for the coldest weather of the drying season and should allow for a generous safety factor in addition.

Volume of Air Required

Air is preferred for dehydration purposes to the use of directly applied heat because overheating of the product is easily avoided; air is convenient to use; equipment for its use is cheap and it permits of easy regulation of the rate of drying and other conditions. It performs two functions in the dehydrator. It conveys heat to the material to be dried, thereby causing evaporation of the moisture, and secondly, it carries away this moisture.

The air must leave the evaporator at a high enough temperature to hold all of the moisture absorbed by it during its passage through the evaporator. Therefore there is a limit to the temperature drop in the evaporator, and for the same reason a limit to the fuel efficiency attainable under usual drying conditions. On hot summer days it is possible to obtain rapid drying by means of a blast of air not artificially heated, or such air may be artificially heated a few degrees only before use. In such cases use is made of the sun's heat, and any

[3]E. Hausbrand, "Drying by Means of Air and Steam," translated by Wright and published by Scott Greenwood & Co.

calculation of fuel efficiency would have to take this fact into account.

The capacity of air to take up water vapor increases rapidly as the temperature rises. The moisture-absorbing power is approximately doubled by each 27 deg. F. rise in temperature. For example, at 128 deg. F. 350 cu.ft. of air will contain at saturation about 2 lb. of water vapor and at 155 deg. F. about 4 lb. Therefore in calculating the volume of air necessary to carry away from the evaporator the liberated moisture it is necessary to take into account its temperature.

In designing an evaporator, however, the volume of air necessary is not determined by the amount needed to carry away the liberated moisture, but rather by the volume necessary to convey sufficient heat to the product to be dried to cause the desired rapidity of evaporation, because a much larger volume of air is required to furnish the necessary B.t.u. than is required for removal of moisture. For example, at drying temperatures in most common use about 63,000 cu.ft. of air dropping 1 deg. Fahrenheit is required to furnish heat to evaporate 1 lb. of water. Under average conditions the temperature drop will be about 50 deg. F., or the amount of air required to evaporate each pound of water will be $63,000 \div 50 = 1,260$ cu.ft. Since air expands upon heating, larger volumes are required for each 1 deg. F. drop at higher than at lower temperatures.

An evaporator, holding five tons of fresh fruit, which must be dried to one-fifth its original weight in a drying time of fifteen hours, under a temperature drop of 50 deg. F. for the air used, would require an air flow of

$\frac{8,000 \times 63,000}{15 \times 50 \times 60} = 11,200$ cu.ft. per minute, since the amount of water to be removed is 8,000 lb.

Experience demonstrates that this amount of air is a minimum for the conditions cited.

Effect of Humidity

For evaporation of water from a free surface the rate of evaporation varies inversely with the relative humidity of the air. This rule does not always hold for the evaporation of water from fruits or vegetables, because of the tendency of some products to "case-harden." Case-hardening is a toughening of the surface—i.e., formation of a semi-impervious film—and greatly retards the rate of evaporation. Case-hardening is caused by the water evaporating more rapidly from the surface than it can be replaced by diffusion from the tissues. It is a result of use of air of too low relative humidity and can be corrected by increase of the relative humidity to the point where diffusion to the surface keeps pace with evaporation from the surface. Pears and potatoes are notable examples of products which case-harden badly. Control of humidity in drying is, therefore, of very great importance and is one of the fundamental principles which are urgently in need of further investigation. Preliminary experiments indicate that the use of air of relatively high humidity (30 to 50 per cent) has very much wider application than was formerly supposed.

Air Velocity

Other things being equal, the rate of evaporation of water from a free surface varies directly in proportion to the rate of application of heat. Since the transfer of heat from air to the material to be dried varies with the square root of the velocity of the air, then the rate of evaporation should vary in like ratio, that is, in proportion to the square root of the air velocity.

There is a practical limit to the air velocity to be used in practice because of rapid increase of static pressure at high velocities. According to Hausbrand[4] a velocity of 1,150 ft. per minute over the drying trays and of 570 in flues between the fan and drying tunnel should not be exceeded. Our own observations confirm Hausbrand's recommendations.

Less air, and therefore a lower velocity, is required at higher temperatures than at lower temperatures. Thus at 158 deg. F. and 122 deg. F. the relative volumes of air required for the evaporation are in the ratio 5,775 : 9,809 if the outside air is at 58 deg. F. Some evaporators tested by the writer are capable of delivering an air velocity of 900 ft. per minute across the drying trays, but the usual flow is less than 400 ft. per minute. The writer would recommend a velocity 700 to 1,000 ft. per minute.

Recirculation

Since less than 25 per cent as much air is required to carry away evaporated moisture as is necessary to furnish the necessary heat units, it is, theoretically at least, economical to return at least 75 per cent of the spent air to the heating chamber, reheat it and use it again. This has been proved in commercial operation to be good practice. A large flue above or below or beside the drying tunnel can be used to return the air, and air outlets and intakes can be adjusted to maintain the desired ratio of intake to outlet air.

Where case-hardening is encountered, recirculation affords one means of increasing the humidity of the air.

The return flue should be large and the air velocity therein should not exceed 500 ft. per minute.

Critical Temperatures

Although high temperatures of drying give more rapid drying and more efficient use of fuel, there is a temperature for each product either at the beginning or the end of the drying period above which rapid breaking down of the tissues occur or caramelization takes place. We may term this maximum temperature as the critical temperature for the product in question. Caramelization and injury to flavor are more apt to occur near the end of the drying period. Freshly cut apples, or peaches or fresh grapes will withstand very satisfactorily temperatures of at least 195 deg. F., but near the end of the drying period, when the moisture content is low, caramelization will occur rapidly at 175 deg. F. For most fruits a finishing temperature above 150 deg. F. should not be used. Dried vegetables "come back" or "refresh"—that is, reabsorb water more rapidly and return to the more nearly the fresh weight and appearance—if dried at temperatures below 150 deg. F. than if dried at 160 to 165 deg. F.

Higher air velocities and lower drying temperatures will improve the quality of all dehydrated products without lengthening the drying time. These changes are badly needed in many plants.

Types of Dehydrators

There are in use on the Pacific Coast two important types of air current dehydrators. In one of these the heated air rises naturally between and across the pieces of product to be dried. In the other the air by means

[4]E. Hausbrand, "Drying by Means of Air and Steam"; Longmans, Green & Co.

of a fan is blown or drawn across or between the pieces of material to be dried.

There are many forms of each type. The Oregon tunnel is the most important form of natural draft evaporator in use on Pacific Coast. One form of Oregon tunnel consists of a concrete or brick furnace room about 18 x 10 ft. in size and about 10 to 12 ft. high, surmounted by several sloping tunnels each about 3 x 5 x 20 ft. in size. The furnace room contains two wood burning furnaces and about 35 ft. of 12 or 14 in. sheet metal pipe. The air is admitted at the base of furnace room walls; is heated by contact with the furnaces and pipes, and rises through the tunnel and across the trays to a ventilator at the upper end of the tunnel.

The stack evaporator consists of a cabinet containing trays set over a furnace room similar to that used for the Oregon tunnel. The air rises through the trays.

The apple kiln form of evaporator consists of a grated floor above a furnace room.

Any of these three forms may be equipped with a fan and the air flow thereby increased, but it has been found much more satisfactory to construct longer and nearly horizontal tunnels through which a blast of heated air is passed across the trays or conveyor of material to be dried. This form permits of recirculation of the air and accurate control of temperature and humidity. To date, the car and tray system of handling the drying fruit or vegetables has proved more satisfactory than the endless metal cloth or belt conveyor system, because of waste of space, sticking of dried material and non-uniformity of drying in the latter.

Many patents have been issued for evaporators and attachments. One man holds a patent upon the use of drying temperatures between 125 and 156 deg. F. Everyone who dehydrates fruit is infringing on his patent. Another holds a patent for drying by means of air drawn across the product to be dried. Infringements are numerous. A few patent suits would clear the situation.

The writer prefers the tunnel type of drier, recirculating air flow, suction fan, and car and tray system. It has proved much more efficient than the natural draft types by actual test.

Results of Experiments

Very important results have been obtained by investigators of the U. S. Department of Agriculture, the state experiment stations, and commercial engineers and chemists. All of these cannot be enumerated here. A few typical results only will be offered.

As before intimated, the horizontal (or nearly horizontal) blast, tunnel type of drier with a recirculation system has proved more efficient and more economical of labor than the natural draft types.

High relative humidity of the air used in drying has been found necessary for products which case-harden—e.g., for pears, potatoes, tomatoes, large prunes and peaches. Most vegetables must be dried to a very low moisture content (less than 8 per cent) to prevent considerable changes in flavor and color.

Vacuum fumigation with CS_2 or heating to 145 deg. F. is effective against insect eggs. Not only the product but also the container (carton, box or can) should be treated, as the latter often contains eggs of the Indian meal moth, the most serious pest to dehydrated products. Low moisture content discourages their growth. Storage at 32 deg. F. will destroy insects and eggs.

Moderate temperatures (below 150 deg. F., preferably below 140 deg. F.) give the best products.

Static pressure (air resistance) has been greatly underestimated by many builders of dehydrators. Tests have shown that flues must be large and sharp angles in flues or tunnels avoided.

Higher velocity of air than is now in common use has proved economical and desirable. A velocity of 800 ft. per minute is recommended.

Blanching (partial precooking) of most vegetables has been shown to be desirable, because it hastens drying, destroys enzymes which would otherwise cause darkening and loss of flavor in the dried product, and because blanching improves and "sets" the color.

Very little sulphuring before drying is necessary for fruits to be dehydrated—much less than for sun-drying. Immersion in dilute salt solution still further reduces the length of sulphuring.

Dipping grapes in boiling dilute lye for a few seconds cracks the skins and shortens the drying period to half or quarter the time required for undipped grapes.

Wine grapes have been dehydrated in enormous quantities in California. (For the preparation of home-made "grape juice"? Draw your own conclusions!) Tests have shown that such raisins may be stemmed, seeded and used for making pies, puddings, etc.

The antiscorbutic value of dehydrated vegetables, especially spinach, is being studied by several investigators. Definite statements on this point would be premature at this time.

Canadian Gas Industry in 1918

The Canadian Bureau of Statistics has just issued an account of the illuminating and fuel gas industry in 1918, being advance sheets of Chemical and Allied Products of Canada in 1918.

There were thirty-eight plants in operation during the year, representing a capital investment for lands, buildings and equipment of $23,577,224, and employing 1,932 persons at an average wage of $957 per year. Five kinds of gas were manufactured—namely, straight coal gas and carburetted water gas, which sold at an average of $1.20 per 1,000 cu.ft.; mixed coal and water gas, and mixed coal and oil gas, which sold at an average price of 85c. per thousand; and acetylene, which brought an average of $16 per thousand. The average price obtained for the coke produced was $5.66 per ton. The cost of the coal, oil, calcium carbide and other supplies was $3,456,396; wages amounted to $1,849,167; and rent, taxes, upkeep, etc., $982,306, making a total of $6,287,869. The sale of gas, coke and byproducts realized $7,282,147, and the rent and sale of meters, lamps, etc., $810,826, making a total of $8,092,937, and showing a profit of $1,805,104, which amounts to 7⅔ per cent interest on the capital investment.

Twenty of the thirty-eight plants are situated in Ontario, eight in Manitoba, four in Saskatchewan, three in British Columbia, two in Quebec and one in Nova Scotia. It is a little curious that the principal coal-producing provinces of the Dominion—Nova Scotia, Alberta, and British Columbia—should have only four plants among them, while Ontario, Manitoba and Quebec, which produce no coal, have thirty of the thirty-eight plants. The report does not deal with natural gas, which is used extensively in Alberta, Saskatchewan and Ontario, and in smaller quantities in New Brunswick.

Water-Cooled Acid Chambers Adopted in England

Description of the Mills-Packard Water-Cooled Sulphuric Acid Chambers—Seven Years' Industrial Expansion—Design of the Frustum Chamber—Lead, Steel and Cooling Water Used—Economic Advantages Obtained

BY ANDREW M. FAIRLIE*

THE first acid chambers of the Mills-Packard type[1] were built for Edward Packard & Co. at Bramford, near Ipswich, England, in the year 1914. There were two of these chambers, built as replacement of part of an old plant, and they have a rectangular chamber of the ordinary type operating in conjunction with them. However, before connecting these two new chambers to the old rectangular chamber, they were operated for some time by themselves, as an experiment, which proved so successful that it led to the construction of similar chambers at other plants. In 1916 twenty-four chambers of this type were built at eight different plants, all in England, for six different companies. Of these eight plants, three had these chambers exclusively and five had rectangular chambers of the ordinary type in conjunction. In 1917 eighteen Mills-Packard chambers were built, at seven different plants for five different companies, all in England. In 1918 only nine of these chambers were erected, and these were for three different companies, all in England, making a total, up to the close of 1918, of fifty-three Mills-Packard chambers, built or under construction.

While the expansion of the invention had proceeded quite rapidly in England, the war had interfered with its development in foreign countries. The first installation of these chambers outside of the British Isles was at Auckland, New Zealand, where a plant of eight chambers was built in 1918-19. During 1920, in addition to nineteen chambers built at four different plants in England, sixteen of the chambers were erected for two different companies in France, and fourteen for two different companies in Italy—a total of forty-nine chambers for the year 1920, of which all but seven were still under construction at the close of the year. P. Spence & Sons of Farnworth, England, have this year (1921) constructed one additional chamber. Altogether, since 1914 a total of 111 Mills-Packard chambers have been installed or contracted for, located at twenty-seven different plants, and built for twenty-two different companies in four different countries.

OPERATION OF COOLING EFFECT

The invention of this water-cooled chamber was due to the observation of a very common occurrence. In Great Britain it had for many years been the custom to have no building inclosing the acid chambers. A heavy rain in the summer time, following a period of heat, has a marked effect on such chambers, unprotected by so much as a roof, and the cooling of the atmosphere, combined with the effect of the cool rain flowing over the chamber sides, causes a sudden drop in chamber temperatures through the plant, with much easier operation of the process and evidence of excess of nitrous gas within the chambers, which excess could have been saved had allowance been made for the effect of the rain. Mills and Packard had observed this and wondered why water applied continuously to the outside of the chamber curtains might not increase the production capacity of a plant, or reduce the niter consumption, or both. This thought led to the necessity for a chamber of such design as would be appropriate for the application of water on the outside, and the new chamber was the outcome.

DESIGN OF THE CHAMBER

The Mills-Packard chamber is formed in the shape of the frustum of a cone, with either a raised or slightly dished top. The curtains are supported by either wood or steel columns, but steel is preferred. The bottoms of the curtains dip into the acid contained in a lead pan, forming the familiar liquid seal. Fig. 1 shows respectively the elevation, sectional plan and sectional elevation of this type of chamber.

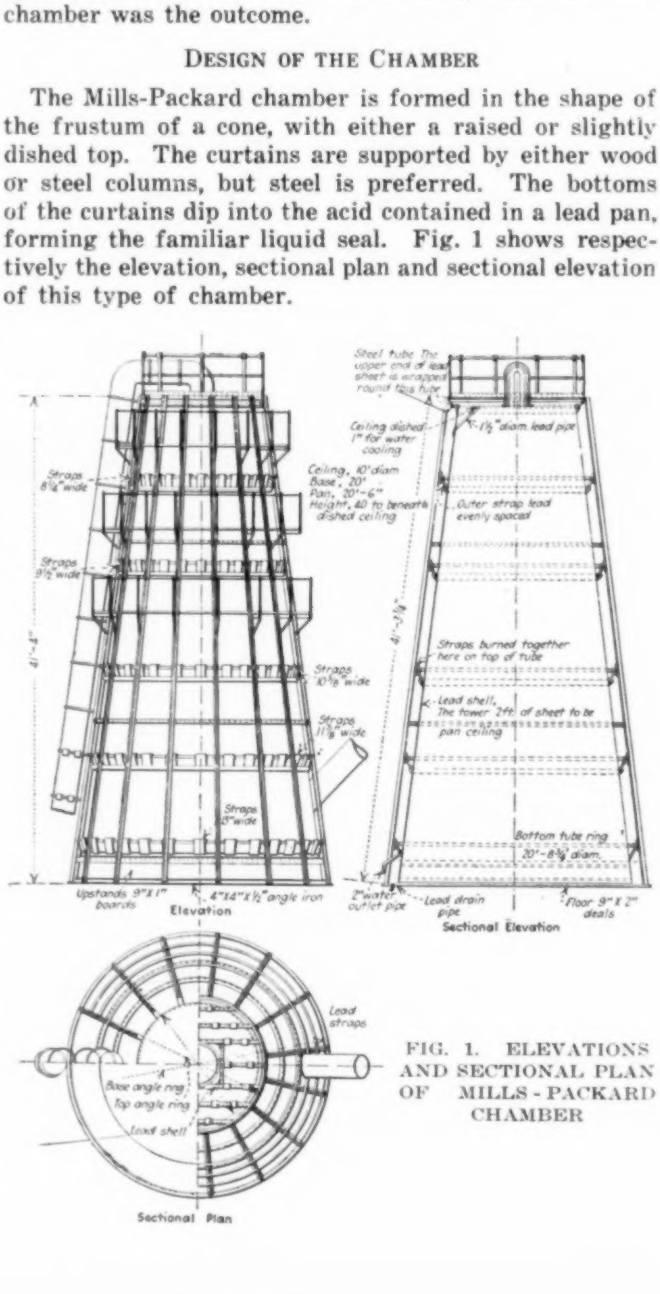


FIG. 1. ELEVATIONS AND SECTIONAL PLAN OF MILLS-PACKARD CHAMBER

*Consulting Chemical Engineer, Atlanta, Ga.

[1]The Mills-Packard patented water-cooled sulphuric acid chamber is the invention of Willie George Mills and Charles Turner Packard, both of Ipswich, County of Suffolk, England. The invention is protected in the United States by U. S. Pats. 1,112,546 (Oct. 6, 1914), 1,312,741 and 1,312,742 (Aug. 12, 1919), and is owned by the firm of Packards & James Fison (Thetford), Ltd., Ipswich, England.

Tabulation of Data on Mills-Packard Installations

Name of Company	Location	Date Built	No. of M.-P. Chambers	Size of Chambers Cu.Ft.	Kind of Chambers	Source of Sulphur	Cu.Ft. Chamber Space per lb. Suphur per 24 Hours	Nitrate of Soda Consumption Per Cent on Sulphur	Ground Space Occupied by M.-P. Chambers Ft.	Remarks
Ed. Packard & Co., Ltd	Bramford, England	1914	2	7,330	2 M.-P. and 1 rectangular	Spent oxide	6.4 to 6.6	3 to 3.5	55x30	Replacement of old plant coupled to existing plant.
F. W. Berk & Co., Ltd	Stratford, England	1916	4	7,330	All M.-P. chambers	Spent oxide	3.8 to 4	...	100x30	Replacement of plant.
F. W. Berk & Co., Ltd	Stratford, England	1916	1	7,330	M.-P., combined with several rectangular chambers	Brimstone	...	...	30x30	
J. & J. White	Glasgow, Scotland	1916	3	7,330	M.-P., with one rectangular chamber	Pyrites	5.6	...	80x26	Replacements of old plant coupled to existing plant.
Spencer Chapman & Messel, Ltd.	Silvertown-London, England	1916	3	7,330	M.-P., with one rectangular chamber	Pyrites	5.8	Abt. 2.8	80x28	Renewal of old plant coupled to existing plant.
Chance & Hunt, Ltd	Oldbury, England	1916	3	7,330	All M.-P. chambers	Zinc blende	4.4	2.4*	80x30	Complete new plant erected.
Chance & Hunt, Ltd	Oldbury, England	1916	2	7,330	M.-P., with rectangular chambers	Pyrites	...	...	56x30	Renewal of old plant coupled to existing plant.
Bolchow Vaughan & Co., Ltd	Ferry Hill, England	1916	6	7,330	All M.-P. chambers	Pyrites	3.6*	4.02*	80x54	*12 months average actually reported.
Egglescliffe Chemical Co., Ltd	Yarm-on-Tees, England	1916	2	7,330	M.-P., with rectangular chambers	Pyrites	9 to 10	...	55x30	Addition to plant. Total cham. space = 227,000 cu.ft. (one unit). M.-P. cham. = 6.4% of total chamber space.
Cwmbran Chemical Co., Ltd	Cwmbran, England	1917	2	7,330	M.-P., combined with 3 rectangular chambers	Pyrites or spent oxide	Abt. 10	...	55x30	No report other than installation is entirely satisfactory.
Cwmbran Chemical Co., Ltd	Cwmbran, England	1917	1	7,330	M.-P., combined with "OPL" plant		Abt. 2.7	...	27x27	
W. Norfolk Farmers Manure Co.	Kings Lynn, England	1917	2	7,330	M.-P., combined with rectangular chambers	Pyrites	Abt. 12 to 13	Abt. 3.0	55x29	Rectangular chambers = 172,424 cu.ft. M.-P. Chambers = 14,660 cu.ft.
Wm. Pearce & Sons, Ltd., amalgamated with Spencer Chapman & Messel, Ltd	Bow-Common, London, Eng	1917	3	7,330	M.-P., combined with one rectangular chamber	Spent oxide	Abt. 6.5	Abt. 3.8	80x30	Addition to existing plant (renewal).
Thomas Jackson & Co., Ltd	Manchester, England	1917	1	7,330	M.-P., with one rectangular chamber	Spent oxide or brimstone	...	...	...	Addition to existing plant (renewal).
P. Spence & Sons, Ltd	Farnworth, nr. Widnes, England	1917	6	11,890	All M.-P. chambers	Pyrites	3.66	3.62*	93x93	*2 months' average (6 chamber unit).
P. Spence & Sons, Ltd	Farnworth, nr. Widnes, England	1917	3	11,890	All M.-P. chambers	Pyrites	3.66	3.62	93x93	(No definite information re 3 ch. plant)
Ed. Packard & Co., Ltd	Bramford, England	1918	3	7,330	M.-P., with 2 rectangular chambers	Pyrites	8 to 10	3 to 4	80x30	
Odams Nitre Phos. & Chem. Co.	London, England	1918	3	7,330	M.-P., with two small rectangular chambers.	Pyrites	...	...	80x28	Addition to existing plant (renewal).
Forbes, Abbot & Lennard	Shoreham-by-Sea, England	1918–19	3	7,330	All M.-P. chambers	Spent oxide and sulphuretted hydrogen	Basis: 3.6 to 4	...	80x29	No report re working of plant.
New Zealand Farmers Fertilizer Co., Ltd	Auckland, New Zealand	1918–19	8	18,750	All M.-P. chambers	Jap. brimstone	Basis: 3.3	...	151x82½	Built but not yet started (information early 1920).
Cleckheaton Chem. Co., Ltd	Cleckheaton, England	1920	7	7,330	All M.-P. chambers	Pyrites	3.6	2 to 3	170x80	Complete new plant erected
Establishment Kuhlmann	Lille, France	1920	12	7,330	All M.-P. chambers	Zinc blende	Basis: Abt. 4.6	...	150x57	In course of erection, complete plant.
Co-operative Cremonese	Cremona, Italy	1920	6	7,330	All M.-P. chambers	Pyrites	Basis: 3.6 to 4	...	81x56½	In course of erection, complete plant.
Primo Consorzio Agrario	Piacenza, Italy	1920	8	7,330	All M.-P. chambers	Pyrites	Basis: 3.6 to 4	...	105x56½	In course of erection, complete plant.
Usines de Produits Chemique D' Hautmont	Hautmont, France	1920	4	7,330	...	...	...	...	...	In course of erection.
Sheffield Chemical Co., Ltd	Sheffield, England	1920	3	7,330	M.-P., with rectangular chambers	Spent oxide	...	...	80x29	In course of erection.
Midland Acid Co., Ltd	Pye Bridge, England	1920	3	7,330	M.-P., with 3 rectangular chambers	Spent oxide	...	...	80x30	In course of erection.
Cwmbran Chemical Co., Ltd	Cwmbran, England	1920–21	6	7,330	...	...	...	...	...	In course of erection.
P. Spence & Sons, Ltd	Farnworth, England	1921	1	11,890	...	...	...	...	...	Addition to plant.

Referring to Fig. 1, it will be noted that the total height of the chamber curtains or walls is divided into five sections, and that at the bottom of each section there is a lead trough completely encircling the chamber. While Fig. 1 shows the chamber walls divided into five sections by five lead troughs, it may be explained that the figure is a drawing of the smallest size chamber and that the larger sizes have a larger number of lead troughs, dividing the chamber walls into a greater number of water-cooled sections. The detail of the lead trough is shown in Fig. 2, an elevation and a section reproduced from the patent specification.[2]

In Fig. 2 a lead gutter 8 is burned to the lead curtain 1 at the bottom of each lead trough 7, and both gutter and trough completely encircle the chamber. The cooling water flowing down the chamber side is collected in the trough 7, from which it flows, through hole 6, into gutter 8, and then escapes from gutter 8 through the serrated notches at the upper outer edge 9, to flow again down the chamber sides to the next trough below. The lead strap hanging vertically in front of the hole 6 is to prevent splashing of water.

Materials Required

These chambers have been built in three sizes, of 7,330, 11,890 and 18,750 cu.ft. capacity each, respectively. The smallest size (7,330 cu.ft.) is 20 ft. in diameter at the base and 10 ft. in diameter at the top and is 40 ft. high. The total weight of lead required for such a chamber, including pan, gas connections, etc., is approximately 12.75 long tons, and the total weight of steel is approximately 5.5 long tons. The storage capacity of the pan of such a chamber is 22.4 tons of chamber acid. The quantity of cooling water required is 250 gal. per hour per chamber.

A larger chamber (11,890 cu.ft. capacity) is 47 ft. high and has a diameter of 23.5 ft. at the base and 11.75 ft. at the top. This chamber requires approximately a total of 8.25 long tons of steel and 19.25 long tons of lead, using throughout lead weighing 7 lb. per sq.ft. The quantity of cooling water required for such a chamber is 350 gal. per hour.

Only one plant consisting of chambers of the largest size (18,750 cu.ft.) has ever been built. That plant was erected at Auckland, New Zealand. A chamber of this largest size requires approximately 23 long tons of lead.

[2]U. S. Pat. 1,312,741.

The tonnage of steel for such a chamber is not known, as the chambers at Auckland had timber supports. The weights given here for the lead required for the three sizes of chambers do not include the lead in false bottoms. If false bottoms are installed, the lead requirements given would be increased by the following weights: For the smallest chamber, 1.1 tons; for the medium chamber, 1.45 tons, and for the largest chamber, 1.6 tons. False bottoms have not been installed except where the platform has been of steel construction. The water used for cooling the outside of the chambers should be reasonably clean, as foreign matter may interfere with the equal distribution of the water

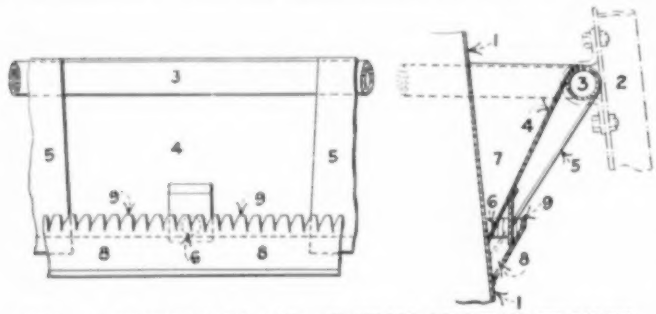


FIG. 2. ELEVATION AND SECTION OF LEAD TROUGH

over the chamber sides, or muddy water may leave a deposit on the lead. Where the cooling water is subject to rapid growth of algæ, the trouble can be eliminated by treatment with a small quantity of copper sulphate. In cleaning the gutters or troughs, care must be taken not to pull them out of shape.

Economic Advantages Obtained

The advantages claimed for these chambers are:

1. The chamber space required per unit of sulphur burned is reduced to from one-half to one-third the usual space.
2. A very material saving in cost of chamber construction per unit of capacity for making acid. The reduction in cost of chamber construction is said to be from 30 to 40 per cent.
3. A substantial saving in ground space per unit of production capacity.
4. Longer life of the lead chambers.
5. Usually no building is required for housing the chambers.
6. Niter consumption, per unit of sulphur made into acid, is no higher than with the ordinary type of chamber.
7. Feasibility of combining one or more Mills-Packard chambers with rectangular chambers of existing plants, or with tower systems, to increase production capacity at small construction cost.

The principal one of these advantages is the reduction in initial cost of plant for producing a given quantity of acid, brought about by the greatly diminished chamber space required per unit of acid made. Actual operating results for plants composed of these chambers exclusively show only 3.5 to 4.5 cu.ft. of chamber space per pound of sulphur burned per twenty-four hours. Built as an adjunct to the rectangular chambers of an old plant, these water-cooled chambers are effective in reducing the total chamber space required.

Operated at a rate of 3.5 to 4.5 cu.ft. per pound sulphur per twenty-four hours, the niter consumption is stated to be no greater than in the ordinary plant employing 8 to 10 cu.ft. per pound of sulphur. Actual operating results show a niter consumption of from 3 to 4 per cent, based on the sulphur burned. It is possible if a Mills-Packard plant were operated at a less intense rate—at a rate, for instance, of 6 to 8 cu.ft. per pound of sulphur in twenty-four hours—that considerable economy in niter consumption might result. No data are available on this point, however, as the demand for acid has been so great that Mills-Packard chambers have been run at the intensive rate of about 3.5 to 4.5 cu.ft. of space per pound of sulphur per day.

Wind Protection Sometimes Required

A view is shown in Fig. 3 of an installation of nine Mills-Packard acid chambers. It is the customary practice, in erecting these chambers, to leave them unhoused. In exceptionally exposed places, however, a light wind screen, to protect the chambers about half way up, is advisable, and such a screen is generally recommended for the chambers of the larger sizes, if the location is at all exposed. With timber framework, complete housing would be considered necessary in some climates, and for this reason steel framework is preferred. The chambers at Auckland, New Zealand, having timber framework, are completely housed, and this is the only fully housed Mills-Packard chamber in existence at the present time. In the case of the nine chambers of the medium size erected for P. Spence & Sons, England, a wind screen of light construction about 25 ft. high was built around the chambers.

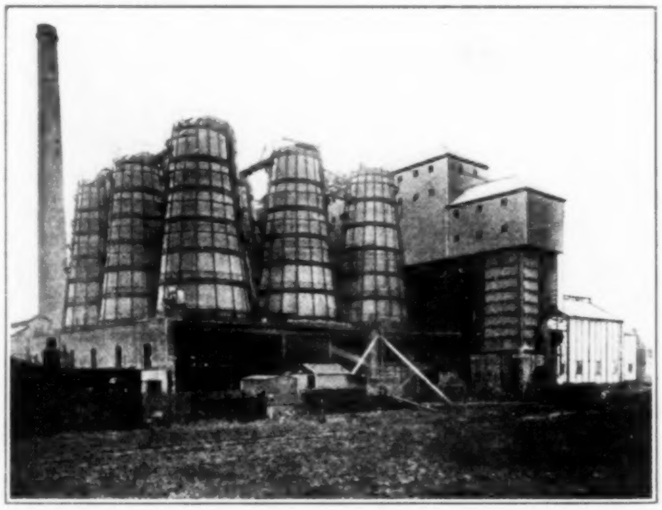


FIG. 3. VIEW OF NINE-CHAMBER MILLS-PACKARD PLANT

Some Typical Data

The operation of this type of chamber, it is claimed, involves no greater supervision than the operation of chambers of the ordinary type. The following table, quoted from a letter dated May 25, 1920, from an English acid manufacturer, gives the chamber temperature for each of six of a set of Mills-Packard chambers of the intermediate size (47 ft. high):

Chamber No.	Temp., Deg. C.	Chamber No.	Temp. Deg. C.
1	77–84	4	50–60
2	62–72	5	30–40
3	60–70	6	20–30

The same manufacturer quoted for these chambers a total chamber space used of 3.66 cu.ft. per pound sulphur burned per twenty-four hours, with a niter consumption of 3.62 per cent, based on sulphur burned, as average

figures for March and April. This manufacturer allowed the chamber drips, in the front chamber, to run as high as 124-132 deg. Tw. (55-57 deg. Bé.). The Packard company, however, recommend chamber drips of not more than 100-115 deg. Tw. (48-53 deg. Bé.), which corresponds to the usual practice in this country.

The maintenance cost for these chambers is said to be very light. As some of the chambers have been erected for seven years, it is possible to get some idea as to upkeep expense. A letter from E. Packard & Co. states that repairs to the lead have been limited, so far as experience at their own plant goes, to a few cracks where the straps were burned to the curtains, and these cracks were easily repaired. Of two samples of lead taken from the curtains of a chamber after five years one showed a loss of 1.89 per cent and the other no loss.

One chamber has been erected in connection with an Opl tower plant in England, and the same company has two Mills-Packard chambers operating in connection with rectangular chambers of the ordinary type. This firm is now building six additional Mills-Packard chambers.

So far no Mills-Packard chamber has been erected in the United States. It has already become quite popular in England, however, and last year the popularity began to spread into continental Europe, indicating sound foundation for the peculiar merits claimed for the external water-cooling.

Legal Notes

By Wellington Gustin

U. S. Supreme Court Holds Burchenal Patent Void for Anticipation by the Normann Process

The decision of the Supreme Court of the United States in the patent case between the Berlin Mills Co. and the Procter & Gamble Co. (41 S. C., 75) presents some interesting facts. The suit was brought by the latter company for infringement of the patent of John J. Burchenal for a food product, issued in 1915, No. 1,135,351, and assigned to it. The District Court held the patent void for lack of invention, but the Circuit Court of Appeals held the patent valid and infringed. (167 C. C. A., 295.)

The patent relates to a product consisting of vegetable oil partially hydrogenized to a homogeneous whitish yellowish product. The record in the case discloses that the making of lard substitutes has been accomplished by mixing melted fat with vegetable oils containing glycerides—olein, linolin and stearin. The hydrogenation, or hardening process, has the effect of increasing the proportion of the solid glycerides of high saturation. Stearin is called a saturated glyceride, for the reason "that there are present in the molecule as many hydrogen atoms as possibly can be joined to the carbon atoms." Linolin and olein are called unsaturated glycerides, and can be converted by the addition of hydrogen into hardened glycerides.

Purposes Set Out by Inventor

The purposes set out and the inventor's intention are as follows: "The special object of the invention is to provide a new food product for a shortening in cooking, in which the liability to become rancid is minimized, and in which the components of such vegetable oils which are inferior and detrimental to use as such a food product have been to a large extent converted into a higher and more wholesome form. All such vegetable oils contain glycerides of unsaturated fatty acids and, among these, notable quantities of fatty glycerides of lower saturation than olein. It is the presence of these glycerides of lower saturation that seriously affects the rancidity, which oxidation weakens the fat at the point of absorption at the double bonds, and these glycerides of lesser saturation readily absorb oxygen from the air at ordinary temperatures, while the more highly saturated glycerides, as olein, only absorb oxygen at elevated temperatures. It is evident, therefore, that oils or fats containing notable quantities of glycerides of linolic acid, or of lesser saturation, are distinctly inferior as an edible product to those containing a minimum of these glycerides with a larger per cent of olein. On the other hand, while it is important to get rid of the readily oxidizable glycerides of lower saturation, it is also important not to supply too large a per cent of fully saturated glycerides. . . . Oil, liquid at the ordinary temperatures, does not make the best shortening because the oil remains liquid, keeping the food in a soggy condition, and the oil will even settle to the under part of the cooked product and soil the cloth, paper or whatever it may come in contact with. Moreover, fats of a melting point above the temperature of the human body, 98 deg. F., are not so digestible as fats which are liquid at this point, or which have a melting point below 98 deg. F. It is therefore my object in the preparation of my new lardlike composition and food product, and in preparing same from cottonseed oil, to change the chemical composition of the oil to obtain a product with a high percentage of olein, a low percentage of linolin and the lesser saturated fats, and with only sufficient stearin to make the product congeal at ordinary temperatures.

Process as Described in the Patent

"In manufacturing this product cottonseed or other vegetable oil is caused to absorb chemically a limited amount of hydrogen by reacting on the oil with hydrogen in the presence of a catalytic agent and at an elevated temperature. The oil is preferably agitated in a closed vessel in the presence of an atmosphere of compressed hydrogen, a catalyzer of finely divided nickel carried by kieselguhr being maintained in suspension in the oil and its temperature being raised to about 155 deg. C.

"According to the present invention the amount of hydrogen absorbed is carefully regulated and limited. In practice, the operation is stopped when the oil has been converted into a product which cools to a white or yellowish semi-solid more closely resembling lard than do the commercial mixtures of cottonseed oil and animal oleostearin, while in many respects the product is superior to the best leaf lard as a shortening. It is not so liable to become rancid, and the product can be heated to a considerably higher temperature than lard without smoking or burning. . . . The high temperature to which my product can be raised without smoking or burning makes the product ideal for frying, inasmuch as a crust forms almost instantly on the food fried, which prevents any absorption of the shortening. A lardlike product thus prepared from cottonseed oil has a saponification value of about 195

and an iodine value ranging from about 55 to about 80. The product having an iodine value of 55 has a titer of about 42 deg. and a melting point of about 40 deg. C., that having an iodine value of 80 has a titer of about 35 deg. and a melting point of about 33 deg. C. While but partially hydrogenized, containing from about 1.5 per cent to 2.5 per cent of additional hydrogen more than in the non-hydrogenized material, it shows no free cottonseed oil when subjected to the Halphen test, thereby differing from all commercial lard substitutes containing this oil. It contains from 20 to 25 per cent of fully saturated glycerides, from 5 to 10 per cent linolin, and from 65 to 75 per cent olein, and an average of a number of samples gives 23 per cent of saturated fats, 7.5 per cent linolin and 69.5 per cent olein, while the cottonseed oil before treatment contained 17 per cent saturated fats, 37 per cent linolin and 46 per cent olein. It will thus be seen that I have produced an ideal food product which is high in olein, low in linolin and lesser saturated fats, and with only enough stearin to make the product congeal at ordinary temperatures."

Two Broad Claims Involved

There are two broad claims of the patent involved in this case. They are:

(1) "A homogeneous lardlike food product, consisting of an incompletely hydrogenized vegetable oil."

(2) "A homogeneous lardlike food product, consisting of incompletely hydrogenized cottonseed oil."

It was necessary for the Supreme Court of the United States to consider what was theretofore known and disclosed in the act. Burchenal, the patentee, was not a chemist, it is said, and was the general manager of the Procter & Gamble Co. One Edwin C. Kayser, who had been in the employ of Crossfield & Son, an English firm, and familiar with the Normann process, to be considered hereinafter, came to this country in 1907 and entered into a contract with Mr. Burchenal whereby an experimental plant was erected at the Procter & Gamble works for hydrogenating oil.

It was the contention of the Procter & Gamble Co. that Burchenal was the first to originate and develop the process involved. The District Court found that he, in fact, invented nothing, and that all that was real invention came from Kayser. But, said the court, considering for the purpose of this discussion that the thought occurred to Burchenal, which he developed in the production of a food product, the primary question presented is whether what Burchenal accomplished amounted to invention within the meaning and protection of the patent law.

This was not claimed to be a process patent, but a product patent of a new and useful thing within the meaning of the patent law. Said the court, if this product were the result of mechanical improvement only, when viewed in the light of that which was previously disclosed and open to public use, the step in advance being only that which one skilled in the art might well make, without the exercise of the originating or inventing faculty, then the achievement is not within the protection of the patent law.

The Normann Patent

The English patent to Normann of October, 1903, disclosed to the world the process of converting unsaturated fatty acids or their glycerides into saturated compounds.

One expert witness gave his views on the Normann process as follows, in part:

"Dr. Normann discovered, and set forth in the patent, that unsaturated acids or unsaturated oils by the action of hydrogen in the presence of finely divided nickel may be converted into corresponding saturated compounds. He says, for instance, if fine nickel powder obtained by reduction in a current of hydrogen is added to chemically pure oleic acid, then the latter heated over an oil bath, and a strong current of hydrogen is caused to pass through it for a sufficient length of time, the oleic acid may be completely converted into stearic acid."

Dr. Normann himself said:

"By causing actylene, ethylene or benzene vapor in mixture with hydrogen gas to pass over one of the said metals, the said investigators obtained from the unsaturated hydrocarbons saturated hydrocarbons, partly with simultaneous condensation.

"I have found that it is easy to convert by this catalytic method unsaturated fatty acids into saturated acids. This may be effected by causing vapors of fatty acid together with hydrogen to pass over the catalytic metal, which is preferably distributed over a suitable support, such as pumice stone. It is sufficient, however, to expose the fat or the fatty acid in a liquid condition to the action of hydrogen and the catalytic substance.

"For instance, if fine nickel powder, obtained by reduction in a current of hydrogen, is added to chemically pure oleic acid, then the latter heated over an oil bath, and a strong current of hydrogen is caused to pass through it for a sufficient length of time, the oleic acid may be completely converted into stearic acid."

Dr. Normann did not specify in his patent any of the purposes for which his patents are intended, or what these products should be used for. It was said they might be used for any purpose for which fats of that general character could be utilized—as for candles, for soaps or for edible purposes. The court found Normann's process was a practicable one, and may be used for making food products of the kind involved in this case.

Was Not Invention, Says Court

With the knowledge disclosed in the Normann patent, was it invention to apply the known process to vegetable oils? The record in the case established that it was known before Burchenal took up the subject that a vegetable oil could be changed into a semi-solid, homogeneous substance by a process of hydrogenation arrested before completion, and that it might be edible. This much of the art was public property and open to general use. The product of this process was known and open to public use, says the court, and to supply such products as the patentee has described in the broad claims in suit may have been new and useful, but did not, in the Supreme Court's opinion, rise to the dignity of invention, and is an advance step which would readily occur to one skilled in the art when he was investigating and considering the subject.

Therefore the Supreme Court reversed the decree of the Court of Appeals and the cause was remanded to the District Court with directions to dismiss the bill on the grounds that claims (1) and (2), set out above, were void.

Constitution of Chromium: Tungsten Steels

Recent Japanese Work Throwing Light Upon the Complex Reactions Giving Self-Hardening and Red-Hardness Properties to Modern High-Speed Steels—Edwards' Views on Like Subjects Are Also Briefly Given

HONDA and Murakami[1] have followed these investigations by a series of tests of steels containing both chromium and tungsten to determine the forms in which these two elements exist after normal slow cooling, their effect upon hardening and tempering and changes in the constituents during heating and cooling.

Three series of steels were used:

(1) W and Cr nearly constant at about 18 per cent and 5 per cent respectively, the carbon varying from 0.33 to 1.26 per cent.

(2) W and C nearly constant at about 18 per cent and 0.65 per cent respectively, the chromium varying from 0 to 7.35 per cent.

(3) Cr and C nearly constant at about 5 per cent and 0.65 per cent respectively, the tungsten varying from 0 to 18.8 per cent.

By similar experimental methods as used in their studies of chromium and tungsten steels as described briefly in CHEMICAL & METALLURGICAL ENGINEERING, vol. 24, pp. 703 and 745, these investigators reached the following conclusions:

1. In steels normally cooled from 900 deg. C. the Ar_2 or Ar_1 transformations occurring at 750 to 700 deg. C. decrease in magnitude almost to suppression. The lowered $Ar_{3\,2}$ transformation[2] becomes conspicuous with increase in carbon from 0.33 to 0.57 per cent. If, however, the carbon content increases beyond 0.85 per cent the normal $Ar_{1\,2\,3}$ transformation once more begins to manifest itself at the expense of $A'_{3.2}$ and finally again is the only one noticed, occurring at the normal point in a steel containing 1.26 per cent carbon, about 18 per cent tungsten and 5 per cent chromium.

In steels similarly cooled from 1,200 deg. C. transformation Ar_1 of low-carbon steels is partially suppressed in magnitude with increasing carbon content. With carbon greater than 0.57 per cent the normal transformation has disappeared. As carbon content increases the temperature of lowered transformation ($A'r_{3.2}$) gradually falls, reaching 100 deg. C. with 1.26 C steel.

2. Chromium in combination with carbon effects the suppression of the Ar_1 transformation, upon which self-hardening depends. With about 0.6 per cent carbon and 18 per cent tungsten 3 per cent of chromium is sufficient to suppress the 700 deg. change, and to effect self-hardening. Higher chromium is only effective in lowering $A'_{3\,2}$ if more carbon is added, which agrees with Edwards' conclusions[3] to the effect that hardness of hardened steels containing 0.6 per cent carbon and 18 per cent tungsten rapidly increases with the addition of chromium from 0 to 3 per cent, but when this element is further increased the effect of this latter increase is almost nil.

3. The effect of adding tungsten to these high-speed steels is principally to diminish the maximum temperature at which, during cooling, the lowering of the transformation takes place. Its effect on the lowering or self-hardening property is small, provided chromium and carbon contents are as given for the steels described by Honda and Murakami. Edwards[3] found the hardness of hardened steels containing definite proportions of chromium and carbon to be nearly constant as tungsten varied up to 12 per cent, but with further increase the hardness gradually became greater.

4. After normal slow cooling from 900 deg. C. a high-speed steel containing about 18 per cent tungsten, 5 per cent chromium and 0.6 per cent carbon consists of iron dissolving tungstide Fe_2W, free tungstide, tungsten carbide (WC), together with the non-magnetic chromium carbide Cr_4C, all in a free state. These may be represented as follows:

$$(Fe + Fe_2W) + (Fe_2W) + (Cr_4C) + (WC)$$

If the steel be heated a little above Ac_1 the carbides dissolve in austenite, but are reprecipitated at the normal Ar_1 point if the maximum temperature does not materially exceed Ac_1. As the temperature of reheating increases, however, chromium carbide dissociates:

$$2Cr_4C = Cr_3C_2 + 5Cr$$
$$3Cr + 2WC + 4Fe = Cr_3C_2 + 2Fe_2W$$

The higher the temperature the more the change proceeds from left to right, the products dissolving in austenite, except remnants of Fe_2W. In normal slow cooling from a high temperature the reverse change takes place to only a small degree, and therefore at room temperature the steel contains the carbides, chromium and part of the tungstide all in solid solution, which condition results in a h rdened steel.

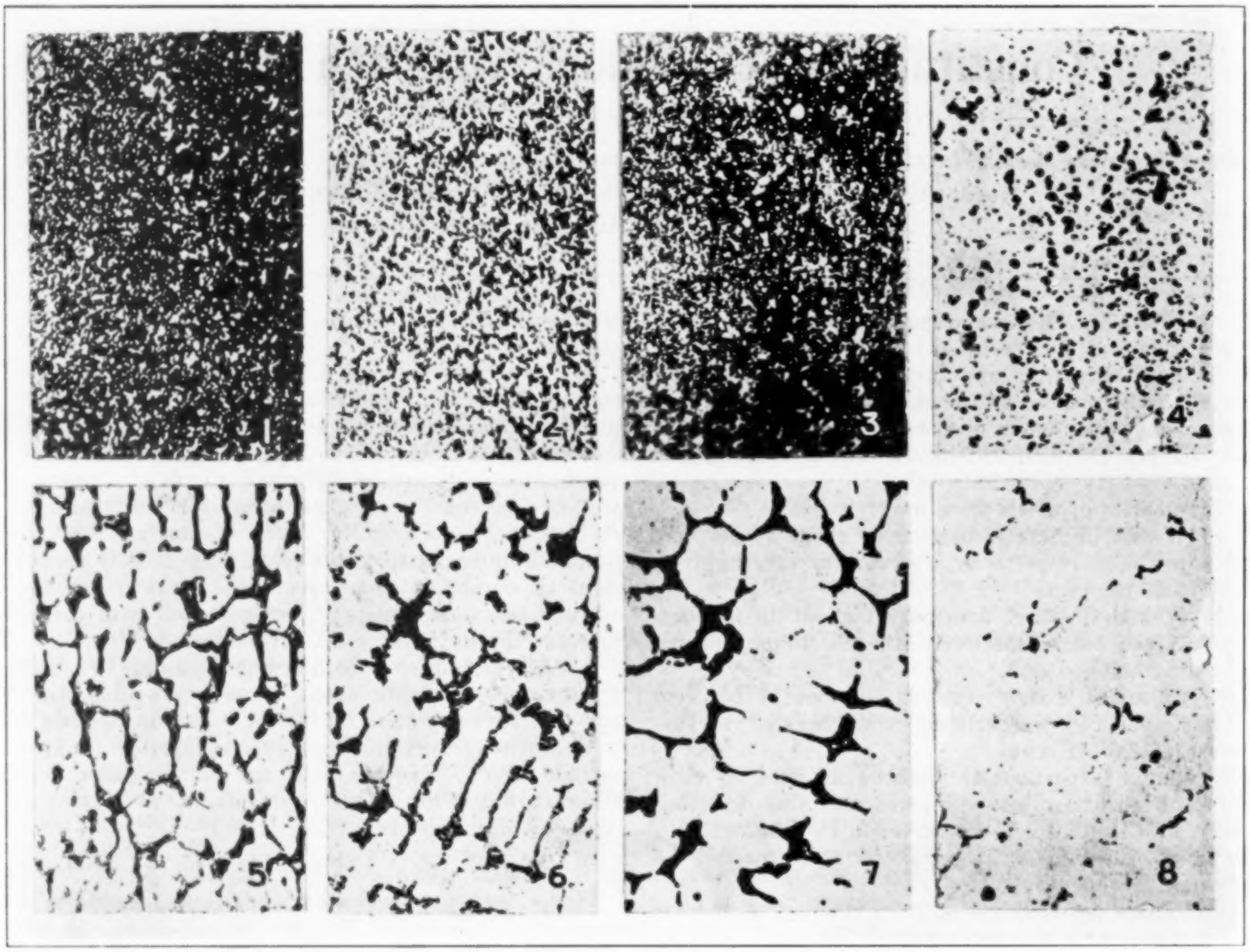
If the specimen thus thermally treated be again heated the dissolved carbide gradually separates, and the steel is tempered in two steps at about 400 deg. C. and 700 deg. C. If the specimen is further heated to the Ac_1 point the free carbide dissolves and the reactions given above proceed from right to left, Cr_4C and WC being formed. Hence by cooling from a temperature a little above the Ac_1 point the carbides Cr_4C and WC separate in the Ar_1 range and we thus obtain the normal structure. The same structure can also be obtained by a sufficiently slow cooling from a very high temperature through the range of 700 deg; because the carbides Cr_4C and WC are slowly formed in this range.

This does not agree, however, with the conclusions reached by Edwards[3] that the lowered critical point (A'r) which occurs in cooling from a high initial temperature is not the cementite change lowered by the presence of tungsten or chromium but a change in a carbide of tungsten which is slowly formed at 1,200

[1] *Sci. Reports*, Tohôku University, vol. 9 (1920), p. 143.

[2] Called by these authors $A'r_{3\,2}$ since they regard it as the superimposed Ar_3 and Ar_2 changes lowered from their position as called for on the Fe:C diagram to 400 deg. C. or less.

[3] *J. Iron & Steel Inst.*, 1908, No. 2, p. 104.



FIGS. 1 TO 8

Fig. 1. Novo steel, 2.86 Cr, 18.81 W, 0.59 C. Annealed, etched with acid. × 190.

Fig. 2. Same as Fig. 1, except etched with $K_3Fe(CN)_6$.

Fig. 5. Steel containing 3.32 Cr, 18.2 W, 0.61 C; cooled from melt. Etched with acid. × 190.

Fig. 6. Steel containing 5.12 Cr, 17.2 W, 0.62 C; cooled from melt. Etched with $K_3Fe(CN)_6$. × 190.

Fig. 3. P. S. high-speed steel, 3,98 Cr, 13.49 W, 0.67 C. Annealed, etched with acid. × 190.

Fig. 4. Same as Fig. 3, except etched with $K_3Fe(CN)_6$.

Fig. 7. Steel containing 4.85 Cr, 16.01 W, 1.0 C; cooled from melt. Etched with $K_3Fe(CN)_6$.

Fig. 8. Steel containing 4.88 Cr, 9.74 W, 0.55 C; cooled from melt. Etched with $K_3Fe(CN)_6$.

deg. C. The absence of the A′r point in specimens cooled from 1,320 deg. C. was ascribed by him to a double carbide of tungsten and chromium formed at high temperatures and held in solid solution even on very slow cooling. Thus he thinks that chromium in high-speed steels forms a double carbide with tungsten, which if held in solid solution imparts high hardness and resistance to tempering. This line of reasoning cannot yet, however, be considered as a true explanation of the function of chromium in high-speed steels.

5. Self-hardening and resistance to tempering increase with chromium and carbon contents conjointly. Increase in maximum temperature or rate of cooling is also intimately connected with the lowering of the transformations. The specific properties of high-speed steel depend principally upon the quantity of dissolved Cr_3C_2 in iron containing chromium and tungstide.

The fine globules appearing under the microscope in slowly cooled high-speed steels in a pearlitic, sorbitic or even troostitic matrix are considered by many investigators to be double carbides of tungsten and chromium or tungsten carbide, because they are colored black in boiling sodium picrate solution. Some investigators, however, believe them to be tungstide, in which opinion Honda and Murakami concur for the following reasons:

1. They have the same properties for chemical reagents as the tungstide found in carbonless iron-tungsten alloys[4] (colored black by picrate or a ferricyanide solution, but remain white when etched in acid).

2. In steels of given carbon and chromium contents they increase in quantity with tungsten content.

3. In steels of given and constant tungsten and chromium contents the globules do not increase but rather decrease with increasing carbon.

As an etching reagent for the globules an alkaline solution of potassium ferricyanide (10 g. KOH and 10 g. $K_3Fe(CN)_6$ in 100 c.c. water) was found satisfactory by these Japanese investigators. Immersion in cold solution for fifteen to twenty seconds colors the globules brown to black, leaving the matrix white. The solution of sodium hydroxide and hydrogen peroxide used by Yatsevitch[5] also colors the globules black in cold solution, but was found to be unstable. It also requires ten to fifteen minutes immersion.

Figs. 1 to 8 inclusive show typical structures obtained by Honda and Murakami in their study of high-speed steels. Figs. 1 to 4 show tungstide globules, white when

[4]See CHEM. & MET. ENG., vol. 24, No. 17, April 27, 1921, p. 746.
[5]*Rev. Met.*, vol. 15 (1918), p. 65.

etched with acid and black when ferricyanide is used, the quantity being greater in the steel of highest tungsten content. Figs. 5 to 8 show the cast structure of various chromium : tungsten steels where the tungstide has segregated in a eutectic form in the primary grain boundaries. This constituent does not increase with carbon and is absent in steels containing less than about 8 per cent tungsten, its quantity being very small in the steel containing 9.74 per cent W shown in Fig. 8.

The action of tungsten, according to Honda and Murakami, when present over 12 per cent, is purely mechanical through the globules of free tungstide, which in a good tool must be uniformly distributed.

Not only are the researches carried on by Honda, Murakami and others of considerable interest but they should react to stimulate further investigation of the fundamentals of the constitution of high-speed tool steels and publication of results obtained. While their various conclusions will be disputed and hypotheses may be successfully overthrown, great credit is due these men in their pioneer work, directed toward the solution of problems involving reactions of great complexity connected with series of steels of the greatest importance.

Electric Furnaces for Melting Non-Ferrous Metals

TESTS on two new types of electric furnaces developed by the General Electric Co. for melting nonferrous metal show a percentage of metal loss for yellow brass of less than 1.5 per cent and less than 0.75 per cent for red brass. The thermal efficiency is high, and the expense for refractories and electrodes is reduced to a low value.

These furnaces have been designed in two sizes, a 1,500-lb. unit and a 50-lb. unit. Either will melt practically any metal requiring a pouring temperature not exceeding 1,500 deg. C. (2,732 deg. F.).

Both furnaces work on the muffled arc principle, the main difference in construction and design being due to the variation in size and the fact that the 1,500-lb. type is three-phase and the 50-lb. is single-phase. The power factor for both is 0.95 or better.

The 1,500-lb. furnace melts yellow brass, pouring at 1,100 deg. C., with a power consumption not exceeding 270 kw.-hr. per ton, operating twenty-four hours a day, with one heat every hour. This gives a total capacity for the furnace of 18 tons of metal in a 24-hour day. The 50-lb. furnace melts yellow brass, pouring at 1,100 deg. C., at the rate of from 100 to 125 lb. per hour, with a power consumption of from 35 to 40 kw.-hr. per 100 lb. of metal, providing the furnace is up to temperature at the beginning of the run.

The 1,500-lb. furnace forms a balanced and very steady load on a polyphase circuit, and is equipped with electrode regulators which automatically maintain the desired power input. It has a shell built of steel plate, lined with standard fireclay shapes, and having a bulged boiler head bottom. The roof frame is hinged to a bar, the shell at the front of the furnace, the same bar carrying a three-legged cast-iron spider which mounts the electrode-supporting mechanism. This permits the whole top of the furnace to be lifted for inspection or repair of the lining without disturbing the electrodes.

Fig. 1 shows the interior arrangement of the three D-shaped muffles, wearing blocks, cross-electrodes and vertical electrodes, which comprise the heating elements. As shown, the space in the muffle between the electrode and wearing block and the side of the muffle is filled with crushed graphite to muffle the arc. The triangular space where the cross-electrodes meet in the middle is filled with a mixture of graphite and tar to insure a good electrical connection.

The 50-lb. furnace is constructed on much the same principle except that in this case the hearth is flat, designed to receive standard graphite crucibles. There

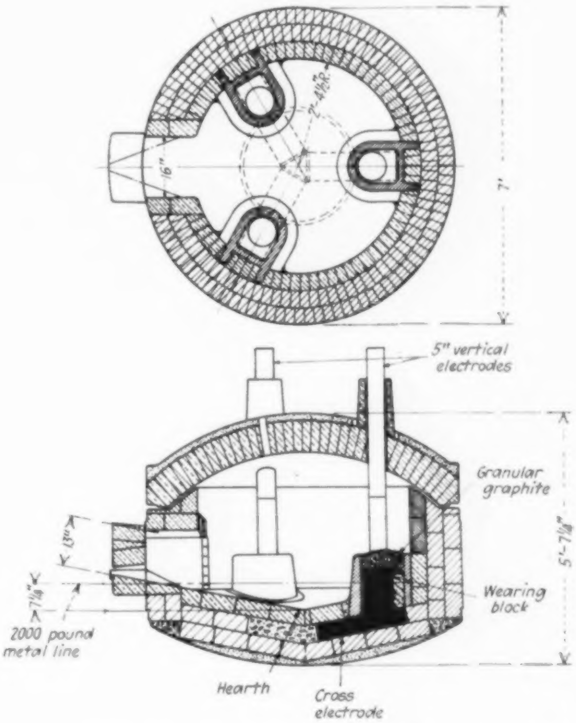


FIG. 1. INTERIOR ARRANGEMENT OF 1,500-LB. HEARTH CAPACITY NON-FERROUS MELTING ELECTRIC FURNACE

is also some difference in the electrode and block arrangement, since the furnace is for single-phase operation. A horizontal carbon block, imbedded in crushed graphite, extends across the bottom, carrying a wearing block on each end. Between these wearing blocks are four carborundum bricks which form the hearth. Two graphite electrodes extend through the roof to the wearing blocks, the arcs being smothered in the graphite surrounding the blocks. The electrode regulation is entirely manual. In operation the crucible containing the metal to be melted is set on the carborundum bricks forming the hearth.

The metal is heated by the same action in both furnaces. The current flows from the vertical electrodes through arcs to the crushed graphite and the wearing blocks. These arcs are smothered by the graphite in the muffles, the whole mass becomes heated, forming a heat source of large area and uniform temperature. The heat is radiated to the metal from all directions as well as being absorbed from the muffles and the hearth.

Not the least of the advantages of the electric furnace are those which influence shop conditions for the better. The absence of dirt and the fumes both from the metal and from burning fuel make the shop atmosphere much more bearable; in addition the electric furnace is practically noiseless. Furthermore, there is comparatively little external heat radiation, and the temperature of the foundry is not raised appreciably.

Acid vs. Basic Electric Furnace For the Foundry

BY F. W. BROOKE*

ACID operation should be adopted when

(1) The sulphur in the scrap is and *always will be* less than the sulphur required in any castings you will be required to make.

(2) The phosphorus in the scrap is and *always will be* less than the phosphorus required in any castings you will be required to make.

A prospective purchaser of an electric furnace, in looking over his available scrap supply, often feels he can obtain all the scrap he requires of a sulphur and phosphorus content low enough (say below 0.04 per cent sulphur and phosphorus) to meet his requirements. The scrap market and the freight situation, it has been our experience, only too often upset his calculations, and he is confronted with the problem of having a high-sulphur and phosphorus scrap and a furnace which cannot eliminate these all-important injurious elements. It has often meant one of three things: (*a*) paying an excessive price for low-sulphur and phosphorus scrap; (*b*) a shut-down until proper scrap can be obtained; or (*c*) bad castings and a dissatisfied customer.

Let us assume that the above situation can be satisfactorily met. There is still the subject of requiring a low-sulphur for special occasions, as for instance the making of a specially difficult casting where the foundry has its own particular difficulties and where a low-sulphur steel would be of particular value in helping out the foundry. This can only be done in a basic furnace.

(3) When the range of carbon and silicon contents will always be wide.

(4) When close physical tests have not to be met.

It is much easier to control the carbon, silicon and manganese in the basic furnace, which means that where specifications have to be met the rejections are much less, particularly on physical tests, such as a good relation between the maximum stress and yield point, and a good elongation with a relatively high maximum stress. This is because of the inherent value of an electric furnace for making refined steels of a quality better than the converter steel, the open-hearth steel and at least equal to crucible quality, which is only present in the basic operation.

Refining can be done in the acid furnace to a limited extent, but calls for skillful operation and is not reliable.

(5) When power consumption and rate of operation are of prime importance.

The acid operation gives a better power consumption in the relation of about 100 to 112, because there is practically no refining in the acid operation. It also gives a less refractory cost, as the cost of raw material is less and the repairs are less frequent.

(6) When very small castings are the sole output.

In making all small steel castings, three important points must be kept in view:

(*a*) Do not have the furnace of too large a capacity—install smaller units and more of them; for instance, where the castings do not exceed 10 to 15 lb. a 1-ton furnace should be the maximum.

(*b*) "Hot" metal is essential, because of the necessity of pouring into shank ladles where the transfer losses and the ladle losses are high and because of the number of "pours" required.

(*c*) It must be easy to hold back the slag and acid slag will keep back and separate more readily.

This does not mean that small castings cannot be made in the basic furnace, but means that in foundries where castings weighing ounces and a maximum of say 25 lb. are to be made, the acid operation is easier and more economical, providing, of course, that the other clauses can be met satisfactorily.

Basic furnaces should be installed for reasons (1) to (4) opposite of those given above, and

(5) When alloy steels are ever to be made in the furnace.

If alloy steels are ever contemplated, a basic furnace is required. Manganese steels, for instance, so often required in the steel foundry industry, can only be economically made in the basic furnace. The use of other elements, particularly chromium, vanadium, etc., can be handled only in the basic furnace, and while the making of alloy steel castings may not be of immediate consideration, their use is becoming more general every day, especially for parts requiring uniform wearing qualities, resistance to shock and resistance to alternating stresses.

(6) When steady load is essential.

A basic furnace invariably has a steadier load than an acid furnace, for two reasons:

(*a*) Higher secondary voltages are used in the acid to bring about more rapid melting.

(*b*) The resistance of an acid slag is higher than the resistance of a basic slag, and therefore also requires a higher voltage.

Both of these calling for a higher secondary voltage causes in practice longer arcs and higher surges because the electrode travel cannot pick up as rapidly.

(7) When refining of cast iron is being considered.

Probably the latest field which is making very rapid strides for the electric furnace in the foundry is for the refining of cast iron. This is particularly applicable to the making of engine cylinders, high-pressure valves, piston rings and parts requiring uniform wearing qualities, etc., and the practice now being adopted is to pass the molten pig iron from the cupola through the electric furnace for a refining period of twenty to forty minutes, which gives: (*a*) A rapid desulphurization. (*b*) Elimination of occluded gases. (*c*) An accurate pouring temperature.

These causes will speak for themselves to the progressive foundryman, who in the past on particular work had gone through periods of worry in his: Sulphur in the coke; blowholes; and "hot" metal and "cold" metal.

Only the basic furnace can be considered for this purpose.

In looking over the number of furnaces recently installed in foundries, it must be surprising to find the large percentage of acid installations. These furnaces were only too often installed by foundries that used electricity as a "fuel" and the electric furnace as the melting pot. They sold their product during a time when there was a loud cry for steel castings and when inspection was either entirely missing or at least lenient. The sulphur and phosphorus specifications and physical requirements were seldom met. This does not mean that the acid furnace had not its own field, but decision should be reached after a careful study of all the existing conditions and as many of the future conditions as possible.

*Vice-President, Electric Furnace Construction Co., Philadelphia.

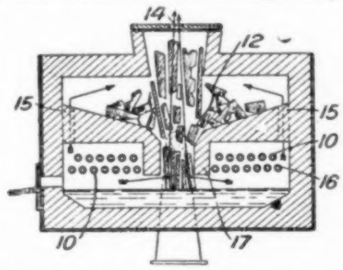
Recent Chemical & Metallurgical Patents

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent Office Southampton Buildings, Chancery Lane, London, England.

Electrolytic Copper.—Elastic or tempered copper is produced by deposition from a sulphate solution on a cathode rotating at a peripheral speed not less than 1,000 ft. per minute. Hardness may be increased by the use of higher speeds, or by addition of say 0.1 per cent of an organic substance such as glue or gelatine, or of arsenic, preferably to the amount of $\frac{1}{16}$ oz. to 1 gal. of 12 per cent copper sulphate solution containing free sulphuric acid. The arsenic may be added in the form of oxide dissolved in 10 per cent caustic soda solution. (Br. Pat. 154,373; S. O. Cowper-Coles, Sunbury on Thames, Jan. 26, 1921.)

Electric Furnace.—In a furnace having resistance bars, free to expand or contract, arranged in the form of one or more grids above the charge, a slight reduction of pressure is maintained to prevent condensation in the openings through which the bars enter the furnace. The charge may consist of copper, nickel, iron, aluminum, brass or materials to be distilled. As shown, the resistance bars 10, which may be of carbides such as silicon carbide, pass loosely through refractory sleeves 16 in the furnace walls. The furnace may be tilted by worm gear so that parts of the charge may be brought nearer to the resistance. The trunnions may form axles for a pair of large wheels which thus support the furnace. In some forms, a hopper 17 is provided in the middle of the roof and between two parts of the resistance. Above the hopper 17 there may be a preheating chamber 12. A slight suction is produced in the furnace by providing an adjustable vent 14 in the cover of the hopper or of the preheating chamber for the vapors which may pass through the hopper or through outlets 15 in the furnace roof. (Br. Pat. 154,444. A. M. Erichsen, Porsgrund, Norway. Jan. 26, 1921.)



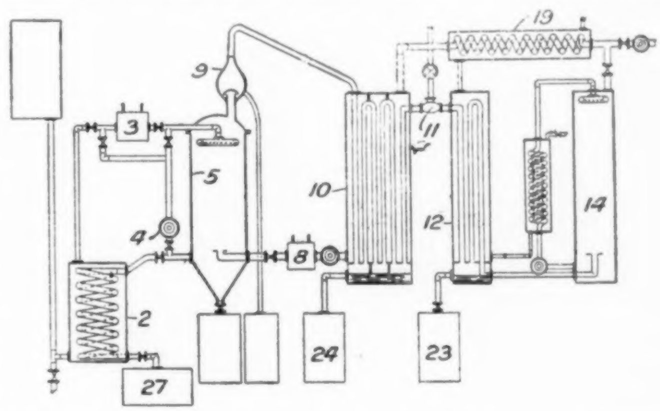
Cracking and Purifying Oils.—Hydrocarbon oils are purified or cracked and purified by heating in presence of sodium or other alkali metal or of an alkali amalgam or alloy such as sodium-lead alloy. The oil and metal may be heated in an autoclave and the oil afterward distilled in the presence or not of the metal; the oil vapor may be passed through the molten metal, or the oil may be fractionated or cracked from a still or retort containing the metal. The process may be continuous or intermittent, and the distillation may be carried out at, above or below atmospheric pressure. (Br. Pat. 154,464; N. V. S. Knibbs, London, Jan. 26, 1921.)

Electrolytic Nickel.—In a cyclic process, nickel is dissolved from ore, matte, or the like to form a solution having an optimum acidity for deposition—i.e., a percentage of free acid between 0.1 and 0.4. The solution is passed in series through the cathode compartments of a number of vats, while a nickel salt solution is passed in series through the anode compartments, the diminution of acidity of the catholyte through electrolysis being compensated for by partial transfusion of the anolyte, which increases in acidity in successive vats. When the acidity of the anolyte has become incompatible with the maintenance of the catholyte acidity below 0.4 per cent, the anolyte is withdrawn and, without concentration, is used for preparing fresh solution to be added to the circulating catholyte. The anolyte may be replenished from the fresh solution or from the catholyte. Each vat preferably contains a number of alternating cathode compartments and insoluble anodes within a single anode compartment, electrolyte being fed in parallel through the cathode compartments of each vat but in series through those of different vats. Diaphragms of clay, wood or paper, or of framed millboard which may be treated with water-glass, are suitable. The catholyte may be at a higher level than the anolyte, so as partly to percolate through the diaphragms. The current density may be 10 amp. per sq.ft. (Br. Pat. 154,471; C. Heberlein, London. Jan. 26, 1921.)

Potassium and Sodium Carbonates.—Technically pure potassium carbonate is obtained by a wet process in which potassium bicarbonate is decomposed with nascent potassium sulphide. The bicarbonate, preferably in granular form, is intimately mixed with finely ground potassium sulphate and barium sulphide and the resulting mixture is added to boiling water. The sulphuretted hydrogen produced is eliminated by boiling or by the passage of steam. The bicarbonate goes into solution with difficulty, but reacts with the nascent potassium sulphide immediately the latter is produced from the barium sulphide. Barium sulphide is regenerated from the precipitated barium sulphate after its removal from the potassium-carbonate solution, from which crystalline or amorphous potassium carbonate may be prepared. By using sodium bicarbonate and sodium sulphate in the place of the corresponding potassium salts, technically pure sodium carbonate may be obtained in a similar manner. (Br. Pat. 154,498; S. Larum, Brussels. Jan. 26, 1921.)

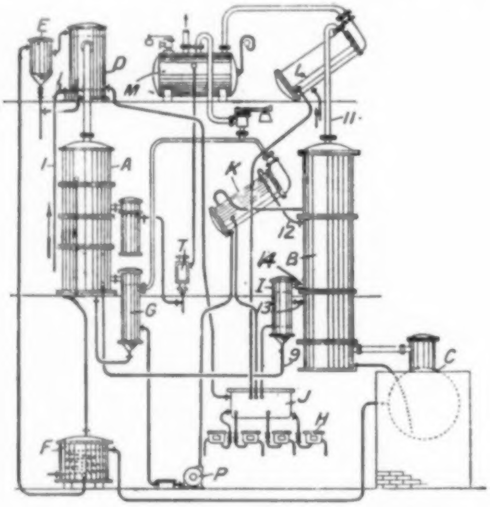
Aldehyde; Acetic Acid.—Acetylene, air and steam are passed over a catalyst at 300 to 400 deg. C. and the resulting aldehyde and acetic acid are condensed fractionally, or first oxidized completely to acetic acid. The weak aldehyde fraction is used to produce the necessary steam. As catalysts are specified basic metallic salts, particularly vanadates, molybdates and chromates. In an example, basic zinc vanadate is precipitated from alkaline ammonium vanadate solution by zinc chloride and deposited on rubbered pumice, the rubber being then burned off in air. (Br. Pat. 154,579, not yet accepted; A. Wohl, Dantzig. Feb. 2, 1921.)

Refining Oils and Fats.—In refining and removing fatty acids from vegetable, animal and fish oils and fats the oil is heated to 200 to 300 deg. F. by passage through a heat exchanger 2 and an electric heater 3, and is sprayed into a refining tower 5, in which it meets an ascending current of carbon dioxide or of carbon dioxide and nitrogen heated if necessary by a heater 8. The partly refined oil may be circulated by a rotary pump 4 and is discharged through the heat exchanger 2 to a reservoir 27. The carbon dioxide and the vapors pass through a separator 9 to a heat-exchanger 10 and thence, after admixture with steam, in



a jet 11, to a condenser 12. Fatty acids condense and collect in receivers 23, 24. The gases may be scrubbed with oil in a scrubber 14, and are led to a gasholder or are returned through the heat exchangers 19, 10 to the tower 5. Cooling-water passes first through a cooler through which the oil from the scrubber 14 is circulated, then through the condenser 12, and then through the heat exchanger 19. (Br. Pat. 154, 514; K. H. Vakil, Bombay, India. Feb. 2, 1921. See also Pat. 155,020, Feb. 9, 1921.)

Distilling Hydrocarbons, Alcohol, etc.—The condensation of vapors in apparatus for distilling crude mineral oils, volatile hydrocarbons, alcoholic liquids, etc., is utilized to generate steam which may be used for heating or power producing. When distilling liquids with a boiling point lower than water, steam is generated under reduced pressure and may be compressed. As applied to a continuous apparatus for distilling crude mineral oil, the oil is passed by a pipe 1, through a dephlegmator *D*, a water separator *E* and a preheater *F* to a column *A* in which petrol vapors are driven off and condensed in the dephlegmator *D*. The oil passes from the column *A* through a pipe 9, heater *I* and pipe 14 to a column *B*. The oil passes from the base of the column to a boiler *C*, the residues from which pass to the preheater *F*. Vapors pass from the column *B* by three pipes 11, 12, 13. The heavy vapors from pipe 13 are condensed in the heater *I*, those from the pipe 12 pass to a steam-generator *K*, which is kept, for example, under a pressure of 6 atmospheres, so that steam is generated at about 189 deg. C. by vapors at a temperature slightly above



this—namely, about 163 to 165 deg. C. The light vapors from the pipe 11 pass to a second steam generator *L*. The steam from the generator *K* may be used in the heater *G*, the condensed water from which is returned to the generator *K* by a pump *P*. Residual steam and the steam from the generator *L* pass to a cylinder *M*, from which the steam may pass for the production of motive power, or may be compressed by a device *T* and used for heating purposes. The various oils condensed pass through a refrigerator *J* to the test glasses *H*. In non-continuous apparatus the vapors from a still are passed through a steam generator on their way to a condenser. (Br. Pat. 154,558, not yet accepted; L. GRANGER, C. MARILLER and SOC. ANON. D'EXPLOITATION DE PROCÉDÉS EVAPORATOIRES, Paris. Feb. 2, 1921.)

Phenol-Aldehyde Condensation Products.—The condensation of phenols with aldehydes, such as formaldehyde solution or paraformaldehyde, is effected or completed in the presence of the following condensing agents which react with the water present or produced—namely, metal carbides, nitrides, cyanamides, silicides or phosphides. Where such bodies are used only for completion of the process, the initial stage of the condensation may be carried out with aqueous formaldehyde by the usual methods, the layer of condensation product separated from the aqueous layer and then treated with the specified condensing agents. According to examples there are employed: Phenol, paraformaldehyde and calcium carbide; cresol, paraformaldehyde and calcium cyanamide or aluminum nitride; an example is also given in which cresol is condensed with aqueous formaldehyde in the presence of ammonium chloride, and the separated resin is treated with calcium carbide. The insoluble infusible products finally obtained are water-free and have high insulating properties. The provisional specifications are not confined to the specific condensing agents mentioned above, and refer also to the use of sodamide, metal alcoholates and the compounds of ammonia with zinc or calcium chloride. (Br. Pat. 154,656, VICKERS, LTD., Westminster, and IOCO RUBBER & WATERPROOFING CO and W. H. NUTTALL, Glasgow. Feb. 2, 1921.)

Alkali Bichromates.—Sodium and potassium chromates are converted into their respective bichromates by the addition of the corresponding acid sulphate. For example, by adding sufficient potassium hydrogen sulphate in the form of a coarse powder to the hot solution of potassium chromate, all the latter is converted into potassium bichromate. After filtering, the solution is concentrated, when potassium sulphate separates. From the mother liquor, after all sulphate has been removed, potassium bichromate is obtained by crystallization. (Br. Pat. 154,810, R. L. DATTA, Calcutta. Feb. 2, 1921.)

Concentrating Ores.—In a froth flotation process for concentrating ores, particularly oxidized ores of copper, lead, etc., the ore is suspended in water to which is added a minute proportion of oleic acid or its near homologues, and a minute proportion of sodium silicate, with or without sodium carbonate, caustic soda or other alkali, and agitation and aëration are effected as usual. The oleic acid or the like may be added at the stage of wet-grinding as described in specification 18,937 (1913). The concentrate may be re-treated with the addition of more sodium silicate but without further addition of oleic acid, etc. The apparatus used may be such as that described in specification 18,937 (1913). (Br. Pat. 154,870, not yet accepted; MINERALS SEPARATION, LTD., London. Feb. 2, 1921.)

Strengthening Organic Tissues and Substances.—The tensile strength of organic tissues and substances such as leather, horsehair, catgut, flax, cotton, etc., is increased by impregnating with "diatomic phenols such as guaiacol, veratrol, etc., in alcoholic or other solutions of varying concentrations." The subsequent evaporation or sublimation of the phenols may be prevented by treating the impregnated material with sodium or potassium formate, carbonate or oxalate, which reacts with the guaiacol or other substance or the surface of the material forming insoluble compounds. (Br. Pat. 154,881, not yet accepted; C. HENRY, Paris. Feb. 2, 1921.)

Alkali and Alkaline Earth Cyanides and Cyanamides.—In the fixation of nitrogen as cyanides or cyanamides of alkali or alkaline earth metals by the reaction of nitrogen on mixtures of alkali or alkaline earth metal compounds and carbon, the materials, which may be briquetted, are introduced into the furnace in a dry condition, that is, containing not more than 2.5 per cent of water so as to be of sufficient electrical conductivity to avoid the production of arcs. When a shaft furnace is employed, the dry condition of the charge prevents the blocking of the furnace by the formation of lumps. (Br. Pat. 154,896, not yet accepted; C. T. THOSSELL and H. L. R. LUNDEN, Gothenburg, Sweden. Feb. 2, 1921.)

Treatment of Waste Micanite.—Scrap micanite and similar insulating materials are treated as follows for the recovery of the resins and the mica. The scrap micanite is autoclaved with a dilute aqueous solution of ammonia or other alkali, or with a solution of a salt having an alkaline reaction such as borax, and the live steam is admitted at a pressure of 4 to 6 atmospheres for fifteen to thirty minutes. Under this treatment the varnish is softened, and owing to the tendency of the mica to regain its original form before compression the solvent penetrates between the layers and dissolves the varnish. Alternatively the micanite is autoclaved with water instead of the alkali and the varnish dissolved after this treatment by immersing the mica while still hot in a cold alkaline solution. The strained alkaline solution, preferably after concentration, is then neutralized and heated to precipitate the resins. (Br. Pat. 155,318; H. C. S. DE WHALLEY and MICANITE & INSULATORS CO., London. Feb. 16, 1921.)

Aromatic Amines.—The reduction of aromatic nitro, nitroso or azo compounds is effected by means of cast-iron borings or turnings and an aqueous solution of a metal chloride, such as sodium, calcium or ferrous chloride; the treatment of nitrobenzene and of nitrophenol benzylethers or their homologues or halogen derivatives is excluded. (Br. Pat. 155,319; T. S. MOORE, Egham Hill, Surrey. Feb. 16, 1921.)

Current Events
in the Chemical and Metallurgical Industries

Study of Non-Metallic Structural Materials Proposed

Congress has been asked by the Bureau of Mines for a supplemental appropriation of $47,000 to undertake a study of the structural clay products and other non-metallic building materials. The proposed work is to be under the immediate direction of Dr. R. B. Moore, chief chemist of the bureau. The appropriation is asked as a result of the many requests which have come to the bureau for information as to the technological phases of structural materials.

Kiln Design and Fuel Economy

An important factor contributing to the market increase in costs of brick and tile is the added expense of fuel. Coal is selling at the mines for three times its pre-war price. The cost of laying it down at clay products plants has doubled, largely due to the increase in freight rates. A large percentage of brick and tile plants is located unfavorably with respect to fuel supplies. Most kilns now in use are very wasteful of fuel. With fuel affecting the price so importantly, the makers of clay products are clamoring for information as to how kiln design may be improved so as to use the minimum amount of coal.

The Bureau of Mines is in a particularly good position to furnish information along the lines set out in the foregoing, as it conducted extensive specialized research work in fuel economy during the war and always has given the general problem much attention.

Breakage of finished brick and tile results in very considerable losses. It is believed that systematic experimentation will develop that this breakage can be reduced materially.

Manufacture of Brick

There are other economies and efficiencies which it is believed the clay industries can adopt. Generally speaking very few important improvements have been made in the manufacture of brick during the past twenty years, it is declared. It is believed that machinery can be improved and that more efficient methods of handling raw materials and finished commodities can be introduced. The matter of a more intelligent selection of raw materials also opens a wide field for research that is likely to be helpful to these industries.

Brick production this year is going forward at one-third the rate of production maintained in 1906. Prices are said to be four to five times higher than those obtained in 1913. Even with the limited amount of construction done in 1919, the country produced $184,000,000 worth of clay structural products. In view of those facts, it is held that any improvement in the practices of the industry will have a direct effect in reducing prices of the finished materials—the greatest obstacle impeding housing construction on a scale commensurate with the country's needs.

Since brick and tile are manufactured for the most part by small operators, the amount of research and experimentation has been relatively much smaller than in the case of industries where there are a limited number of large producers.

Cement, Slate and Feldspar

Cement, slate and feldspar studies also will be undertaken if Congress will make the appropriation. It is proposed to study the extension to building construction the use of "sand cement," which has been employed so successfully in Reclamation Service projects. Improvement is believed possible in the proportioning of materials used in many cements and in the methods used in mixing and grinding.

In such limited investigations of the slate industry as already have been undertaken by the Bureau of Mines, it has been established that the solution of that industry's greatest problem is the finding of uses for waste slate. It has been found that it can be ground and made into a very durable roofing material. It is believed that means can be found for utilizing much of the waste material. The result would be the placing of the industry on a more substantial footing and make possible price reduction.

With the growth of the pottery industry, there is an increasing demand for feldspar of high quality and uniform grade. A thorough survey of the industry is declared to be imperative. The plan is to determine the probable reserves of high-grade feldspar in the United States. Methods of quarrying and grading would be studied with the idea of suggesting improvements. It also is proposed to establish standard grades of this material. It is suggested that the material suitable for electrical porcelain and vitrified whiteware could be graded differently than that suitable for the lower grades of pottery.

New Chemistry Building for Columbia University

Initial steps have been taken by the trustees of Columbia University to carry out the big building program outlined by President Nicholas Murray Butler two years ago. Preparation of plans for two new buildings, one to be devoted to the department of chemistry and the other for use as a faculty club, has been authorized.

The new chemistry building will be thoroughly modern in construction and equipment and will be built on Broadway immediately north of Havemeyer Hall. It will contain provision for instruction and research in chemistry and chemical engineering and allied subjects. The faculty club building, the cost of which two years ago President Butler estimated at $300,000, will be located at Morningside Drive and 117th St., adjoining the president's house. The building program indicated by President Butler at that time called for an expenditure of several million dollars.

It is proposed to erect the chemistry building and the faculty club building with funds recently received by the university in unrestricted legacies.

In a statement prepared for the University Council Dr. Butler says that some of the more urgent physical demands of the university should be satisfied. The weakest point in the university at the present moment is the lack of sufficient equipment for instruction and research, particularly in those fields where extensive laboratories are required.

"Probably no one will dispute the statement that the central science just now," added Dr. Butler, "the one that is likely to remain the central science for some time to come, is that many-sided body of knowledge called chemistry."

Quebec Pulp-Wood Business at Standstill

The pulp-wood business in Quebec, like the lumber trade, is practically at a standstill, reports Vice-Consul Arthur B. Giroux, at Quebec. Quebec dealers interviewed say they cannot account for the lack of demand from the United States except that American mills are still stocked with wood and paper products. The dealers, however, are waiting for readjustment, and state that they can and will wait until conditions are better and the prices assert an upward trend.

Quebec farmers, who for some years past have cut pulp wood from their farm woodlands, have stopped cutting. The tendency is to wait for a settlement of conditions, and it was stated that no more pulp wood would be cut until the prices are increased.

Plan to Extend ad Interim Dye Control

After having heard testimony to the effect that German dyes would be dumped upon the American market if the authority of the War Trade Board were not extended, Senator Knox introduced the following amendment to his peace resolution:

Provided further, that on and after the day following the passage of this act, for the period of six months, no sodium nitrite, dyes, dyestuffs, including crudes, intermediates and other products derived directly or indirectly from coal tar, and no finished or partly finished products, mixtures and compounds of coal-tar products, and no other synthetic organic drugs, or synthetic organic chemicals, shall be admitted to entry or delivered from customs custody in the United States or in any of its possessions unless the Secretary of the Treasury shall determine that such article or a satisfactory substitute therefor is not obtainable in the United States or in any of its possessions on reasonable terms as to quality, price and delivery, and that such article in the quantity to be admitted is required for consumption within six months by an actual consumer in the United States or in any of its possessions, and the Secretary of the Treasury may make all rules and regulations necessary and proper for the accomplishment of the purposes of this proviso. And upon the day following the approval of this act the War Trade Board Section of the Department of State shall cease to exist; all clerks and employees of the said War Trade Board Section shall be transferred to and become clerks and employees of the Treasury Department; all books, documents and other records of the said War Trade Board Section shall become books, documents and records of the Treasury Department; all individual licenses issued by the War Trade Board Section prior to the passage of this act shall remain in effect and the importations under such licenses shall be permitted; all unexpended funds and appropriations for the use and maintenance of the said War Trade Board Section shall become funds and appropriations available to be expended by the Secretary of the Treasury in the exercise of the power and authority conferred upon him by this proviso; and for carrying out of the purposes of this proviso during the fiscal year ending June 30, 1922, the sum of $50,000 is hereby appropriated.

The anti-dumping bill, which was made a part of the emergency tariff legislation, does not protect the chemical industry, since it is so distinct from other classes of production whose protection is sought by that legislation.

Deputation of Engineers Will Present the John Fritz Medal to Sir Robert Hadfield

To express the obligation which the world owes to the engineers of Great Britain for the part they played in winning the war, the organized engineers of America will send a mission to London this summer. This mission, consisting of nationally known engineers and representing the so-called Founder Societies, will make the award of the John Fritz Medal to Sir Robert Hadfield at the opening meeting of the British Institution of Civil Engineers on June 29.

The inability of Sir Robert to come to the United States to receive the medal moved the trustees of the board to make the ceremony of presentation in England the occasion for an international expression of appreciation by the engineers of the United States to the engineers of Great Britain.

The deputation to England will consist of a representative of each of the four Founder Societies represented on the John Fritz Medal Board of Award as follows:

Charles T. Main of Boston, the American Society of Civil Engineers; Colonel Arthur S. Dwight of New York, the American Institute of Mining and Metallurgical Engineers; Ambrose Swasey of Cleveland, the John Fritz Medal Board of Award and the American Society of Mechanical Engineers; Dr. F. B. Jewett of New York, the American Institute of Electrical Engineers. Dr. Ira N. Hollis, president of Worcester Polytechnic Institute and past president of the American Society of Mechanical Engineers, will accompany the deputation and bear the message from the American engineers.

The John Fritz Medal is a gold medal presented for achievement in applied science as a memorial to the engineer whose name it bears. Previous recipients of the medal have been John Fritz, Lord Kelvin, George Westinghouse, Alexander Graham Bell, Thomas Alva Edison, Charles Talbot Porter, Alfred Nobel, Sir William Henry White, Robert Woolston Hunt, John Edson Sweet, James Douglas, Elihu Thomson and Henry Marion Howe. The medal is awarded to Sir Robert Hadfield this year because of his invention of manganese steel.

The medal was established by the professional associates and friends of John Fritz of Bethlehem, Pa., on Aug. 21, 1902, his eightieth birthday, to perpetuate the memory of his achievements in industrial progress. There are no restrictions on account of nationality or sex. The trust funds supporting the medal are held and administered by a board of sixteen directors, consisting of four from each of the four national engineering societies represented on the mission to England.

The admiration felt by the American engineer for his British fellow-worker is expressed by Calvin W. Rice, secretary of the American Society of Mechanical Engineers, in a communication to Dr. J. H. T. Tudsbery, secretary of the Institution of Civil Engineers, London, in response to cabled greetings:

"There is a very deep sense of gratitude and obligation on the part of the engineering societies of the United States for the part played by the engineers of Great Britain in the war, and it has been a great deprivation to us that we could not have sooner expressed this in an adequate manner. It is the desire on the part of the engineers of the United States that the presentation be as simple as possible and yet be sincere."

In response to this communication the British Institution of Civil Engineers cabled that it would "welcome and appreciate very highly greetings from the engineers of America at the opening meeting on June 29," and that they "found the occasion very suitable for the presentation of the John Fritz Medal to Sir Robert Hadfield."

License Required for Importation of Sodium Nitrite From Enemy Territory

The War Trade Board Section of the Department of State announces that General Import License PBF37 has been corrected to include importations of sodium nitrite among the materials, products and commodities importations of which are excepted from its provisions. Specific individual licenses are now required for: (*a*) sodium nitrite, (*b*) synthetic organic drugs, (*c*) synthetic organic chemicals, (*d*) dyes and dyestuffs, including crudes and intermediates, (*e*) all products (whether embraced in the above or not) derived directly or indirectly from coal tar, including crude, intermediate and finished or partly finished products and mixtures and compounds of coal-tar products.

The action in regard to sodium nitrite was taken after conferences between F. S. Dickson, acting chairman of the board, other Government officials, representatives of the American Nitrogen Products Co. of Seattle and representatives of American dye manufacturers. Importation of Norwegian sodium nitrite will not be affected by this ruling.

In addition, a revised and simplified form of instructions for filing applications for licenses has been issued.

Fellowships in Metallurgy

Several fellowships are to be awarded at the University of Utah, Salt Lake City, each having an annual value of $720, open to college graduates with good training in chemistry and metallurgy. The work will be in the department of metallurgical research, University of Utah, which is maintained in connection with the Utah Station of the United States Bureau of Mines. The problems to be studied are in general ore dressing, or special problems bearing on the flotation of ore, application of volatilization process to gold, silver, lead or copper ores, the hydrometallurgy of zinc, or investigations on oil shale. Full details may be had from Joseph F. Merrill, director.

Hoover Requests Additional Funds

To make possible additional assistance to the export industries, the Secretary of Commerce has requested supplemental appropriations aggregating $618,728.34. Of that sum $250,000 is to be used by twelve new divisions which it is proposed to establish in the Bureau of Foreign and Domestic Commerce. It is planned to have a separate division to be of direct assistance to each of the following industries: chemicals (including dyestuffs), cotton and cotton goods, paper and paper products, leather and leather products, machinery, electrical goods, automobile and accessories, lumber and lumber products, metal products, vegetable oils, hardware, jewelry, and silverware. The entire time of two specialists would be devoted to each of the industries mentioned, if Congress should approve Secretary Hoover's plan. In addition each division could make specialized use of the mass of foreign trade information which is constantly reaching the bureau and would keep up to date the market investigations which the bureau has been conducting during the last five years.

An additional $100,000 is requested by Secretary Hoover for an investigation by the Bureau of Standards into industrial wastes and the development of commercial uses for byproducts.

Another $100,000 would be allotted to the Bureau of Standards for an extension of its work in the matter of standardization of equipment. Mr. Hoover holds that it is of first importance to those engaged in foreign commerce to establish manufacturing and commercial standards of machinery, equipment and devices, including the elimination of unnecessary forms, varieties and qualities. He points out that the Department of Commerce is in a position to co-operate with both manufacturers and users in bringing about voluntary standards of this kind.

It is proposed further by Mr. Hoover to allot $50,000 to the Bureau of Standards for the standardization of housing construction, the development and dissemination of knowledge concerning building materials and their uses and the establishment of building codes. Since building codes are of a highly scientific character, Mr. Hoover points out that extensive investigation is necessary so that they may be formulated with due regard to economy, durability, safety and the materials locally obtainable.

The remainder of the fund requested is allotted largely to salary increases throughout the department. Mr. Hoover has stated frequently since taking charge of the department that inadequate salaries form the basis of many of the department's difficulties.

Philadelphia Section Meeting, A.C.S.

A varied program was presented at the regular monthly meeting of the Philadelphia Section of the American Chemical Society, held at the Engineers' Club on Thursday evening, April 21. The dinner speaker was Richard Spillane, editor of the Business Section of the *Public Ledger*. He presented a very interesting and comprehensive survey of business cnditions in Europe and of our foreign trade possibilities throughout the world. He emphasized particularly the splendid opportunity that China offers us in her enormous undeveloped mineral and agricultural resources. South America, with its untapped reservoirs of oil, also offers excellent possibilities. In conclusion, Mr. Spillane made a special appeal to chemists "to meet our friends the public by talking and writing in plain, simple English, so that ordinary people can understand it. Chemistry is enveloped in too much of a fog. Let there be the sun of understanding."

Work of Bureau of Standards

At the formal meeting of the section, W. C. Wagner of the Philadelphia Electric Company spoke on "Recent Developments in the Work of the Bureau of Standards." His talk was illustrated with a large number of slides, many of which were prepared and released expressly for this meeting. Balances were shown ranging from a small assay balance accurate to 0.001 mg. up to a large railroad machine for calibrating track scales. In steel-testing work moving pictures of the gages are taken and the instantaneous readings thus obtained are proving very valuable.

In the electrical work, standards of resistance are in use which are accurate to one millionth of an ohm, and potential differences can be measured with an accuracy of 0.00001 volt. In calibrating electrical instruments a magnifying camera is used for projecting the face of the instrument, and thus, by avoiding parallax, an accurate reading is easily obtained. A magnetic device has been developed for determining the integrity of steel. This was especially applicable during the war in detecting internal flaws in steel for rifle barrels. The relative hardness of different steels can also be determined magnetically. The speaker predicted that one of the important developments along this line in the near future would be the use of this device by the railroad companies for detecting flaws in rails. In studying the electrolytic corrosion of pipe, it has been found that if the moisture content of the earth rises, through faulty drainage, above 18 to 20 per cent, the rate of corrosion increases very rapidly.

In the aëronautical work at the Bureau of Standards, special attention has been paid to the testing of airplane motors. A "stethoscope of the gas engine" has been developed by which a great deal of valuable information has been obtained on the performance of different types of motors. For example, it has been possible to determine the relation between the viscosity of the lubricating oil and the electric power required to start the motor. Pictures were shown of the "vacuum chamber" where Liberty motors were tested under the same conditions as would be encountered in actual service.

Several other interesting phases of the work were mentioned. In the radio work, antennæ were developed for use on airplanes, so that, with the instruments in the landing field sounding a certain keynote, a safe landing could be made in total darkness. In the radium section, flaws in steel plates are detected by means of radium photographs. The photographic section has developed improved plates for taking airplane pictures in smoky or foggy weather. Mr. Wagner concluded by praising the Bureau of Standards for its excellent work on optical glass.

Refractometry

The last speaker on the program was Warren P. Valentine, who gave an illustrated talk on "Refractometry." He discussed the principles of refraction and the different types of instruments that are based on the principle of total reflection. There is a definite relation between the percentage of solid in a solution and the refractive index. The refractometer can therefore be used for the analysis of almost any solution that is clear enough to transmit light. It can also be used to determine specific gravity, and when used for this purpose special scales can be set on the instrument. Mr. Valentine has manufactured the first American Abbe-type refractometer, and the Bureau of Standards has certified that the accuracy of his instrument is greater than that of any refractometer heretofore imported from Europe.

Oil-Fired Converters

Three Scottish firms have installed the Stock oil-fired converter for the manufacture of steel castings, according to *The Iron Monger* for March 26, 1921. The Stock is a small side-blow converter in which the cold pig iron and scrap can be melted before deoxidation by means of oil fuel, which is introduced at a pressure of about 40 lb. per sq.in., and for the combustion of which a suitable supply of air is admitted. Melting occupies from forty minutes to an hour, and when this is completed the oil is cut off and the converter is rotated into a slanting position. A blast of heated air is then introduced from the side of the converter at such a level that it produces agitation only at the surface of the metal. Blowing usually occupies about a quarter of an hour. The main advantages of this method are that no impurities are taken up by the pig iron during melting, and that the high temperature obtained results in a very fluid metal which makes the process very suitable for the production of castings.

Inspection Trips at A.S.M.E. Spring Meeting, Chicago

Industrial Chicago has many things to show the mechanical engineer, and is going to throw them open to inspection by those attending the spring meeting of the American Society of Mechanical Engineers, May 23 to 26. The places which offer to entertain guests in this way are too numerous to be seen by all within the four days of the meeting, so several are scheduled for each day, so arranged, as far as possible, that the individual may suit his taste by selection daily without feeling that he is missing something he would like to see.

Tuesday: International Harvester Co., McCormick and Deering plants; Sears, Roebuck & Co., wall paper manufacture, handling and shipping merchandise; Mandel Bros., package handling, coal and ash handling, connection to sub-street tunnel system; Western Electric Co., manufacture of telephone apparatus and cable for the bell telephone system.

Wednesday: Illinois Steel Co., South Works, South Chicago, plate mill, rail mill, bessemer converters and general steel mill equipment; Commonwealth Edison Co., modern turbine central station at Fisk St.; Pennsylvania Lines terminal, freight handling plant, in connection with which there may be visited the neighboring warehouse of Marshall Field & Co. and the U. S. Terminal Building; Crane Co., manufacture of valves and fittings in cast iron, malleable iron, steel and brass, the fabrication of pipe work.

Thursday: Chicago Mill & Lumber Co., 120-in. paper machine, manufacture of fiber, corrugated board and paper boxes; Clemetsen Co., manufacture of veneers and "Clemco" office desks; Pullman Co., Pullman cars, passenger coaches and freight cars; Underwriters Laboratories, testing of appliances and devices for fire prevention; Yellow Cab Manufacturing Co., where the ubiquitous cabs come from.

Friday: Milwaukee Railway & Light Co.'s Lakeside plant, trip by rail to Milwaukee, boilers fired with powdered coal; Joseph T. Ryerson & Sons Co., warehouses of about 1,000,000 sq.ft. devoted to machinery and steel products.

Chicago Chemists Discuss Photochemistry and Elect Officers

On Friday evening, April 22, the Chicago section, A.C.S., met in Steven's Restaurant, having as guest of the evening Prof. J. H. Mathews of the University of Wisconsin. Members of the Chicago Microscopical Society and of the Camera Club also attended. In the absence of Prof. W. Lee Lewis, Dr. Ethel M. Terry presided.

The speaker's topic was Photochemistry. He pointed out that the use of chlorophyl in vegetation as a photochemical sensitizing agent does not preclude the possibility of finding other chemical agents which may be much superior. Furthermore, the sun is not a satisfactory source of light for photochemical research, because of its inconstancy of energy intensity. The best approach so far to an ideal is a mercury vapor lamp. The spectrum lines in this lamp can be increased by the addition of various other metals, forming amalgams. Of interest is the fact that because the eye is sensitive to only a portion of the spectrum, benzene and acetone are looked upon as colorless, though they both yield definite lines in the spectrum.

In reference to the bactericidal action of rays, Prof. Mathews' belief is that the ultra-violet ray will never be of commercial value for the sterilization of milk. He also spoke of a "new" method of pasteurization recently announced in Detroit whereby milk is treated by the electric current—but, as he cleverly pointed out, the heat generated is equal to that employed in the usual pasteurization plants!

Preceding the talk, the annual balloting for officers occurred. W. Lee Lewis was re-elected chairman; H. G. Walker was elected first vice-chairman, O. C. Stanger second vice-chairman, S. L. Redman secretary, Otto Berndt treasurer, Paul Van Cleef editor, R. E. Doolittle, P. N. Leech, H. N. McCoy, C. S. Miner, L. V. Redman, W. R. Smith, A. M. Taylor, L. M. Tolman and G. L. Wendt councilors. The Willard Gibbs jurors chosen were W. D. Harkins, Julius Stieglitz, E. W. Washburn and David Wesson.

Molybdenum Steel

"Molybdenum Steel" was the subject at the April meeting of the American Society for Steel Treating, Washington Section, on April 22. Dr. George W. Sargent of the Molybdenum Corporation of America discussed the occurrence and characteristics of the richer ores of molybdenum now being mined in this country. By comparisons with other metals and assisted by lantern slides, he brought out some of the history of the uses and the present practice which has led to the application of molybdenum in various carbon and alloy steels. He emphasized particularly the possibility of substitution of molybdenum for carbon in some of the heavier rails now used and in some structural metal.

Martin H. Schmid, speaking at the same meeting, brought out some of his experiences as the metallurgist of the United Alloy Steel Corporation. He emphasized particularly the substitution of molybdenum in smaller percentages than formerly deemed the best practice. The possibilities of molybdenum in chromium, nickel or other alloy steels were also pointed out, with particular attention to the formation of double carbides and the beneficial effect due to diffusion in the ferrite in chrome-molybdenum alloys. Some of the considerations guiding a customer in his selections of an alloy steel were stated by Mr. Schmid as follows:

(1) Compliance with specifications. (2) Availability of raw materials. (3) Freedom from patent litigation. (4) Uniformity of commercial product. (5) Responsiveness to thermal manipulation with reasonably wide temperature ranges. (6) Satisfactory mechanical performance and machinability.

The several methods of adding molybdenum to steel were considered and the advantages of each procedure pointed out. The standard practice suggested by Mr. Schmid is the addition to the charge in the furnace while melting down, as this is claimed to give better diffusion and superior uniformity of finished product. Mr. Schmid also discussed the possibilities of molybdenum steels from the standpoint of the shop and the rolling mill. This metal apparently rolls well without special precautions and permits of wide temperature ranges during working, either rolling or forging. The scale is loose and is easily eliminated, as it flakes freely from the metal and does not show a tendency to roll into the surface. As a result cleaner forgings which require a minimum of expense for cleaning are generally obtainable. The wide range of quenching temperatures which can be used is also cited as an advantage in contrast with certain other steels, the preparation of which requires very close temperature control.

The Washington Section at its next meeting, May 18, will have two speakers dealing with the heat-treatment of ordnance steel and heavy forgings. P. E. McKinney of the Washington Navy Yard, and Lawford H. Fry, production manager of the Standard Steel Works, will be the speakers. At the June meeting, Dr. Enrique Touceda will speak on malleable iron.

Dyes Discussed at Meeting of Connecticut Valley Section, T.A.P.P.I.

The April meeting of the Connecticut Valley Section of the Technical Association of the Pulp and Paper Industry, held in Holyoke April 20 was featured by an address on "Dye Manufacture" by W. F. Van Riper of E. I. du Pont de Nemours & Co. Mr. Van Riper exhibited motion pictures showing various steps in the manufacture of dyes.

In his talk he outlined the growth of the American dye industry during and since the war and stressed the importance of dyestuff manufacture to a nation not only because of its peculiar situation as a key industry on which many other products are dependent but also because of its potential value as a source of military explosives in case of war.

Of particular interest to the paper makers gathered to hear him was his description of factory standardization of colors, for a paper maker must know that one lot of color will be like another in tone and shade, else there is trouble.

After the address many questions were asked the speaker and some interesting experiences with colors brought out.

Personal

HOWARD C. ARNOLD, formerly chief chemist and plant manager of B. F. Drakenfeld & Co., manufacturer of ceramic colors, 50 Murray St., New York, has joined the staff of Arthur D. Little, Inc., Cambridge, Mass.

H. FOSTER BAIN has been nominated by the President to continue his present incumbency as Director of the U. S. Bureau of Mines.

Dr. OSKAR BANDISCH, formerly Privat Docent in the University of Zurich and student under Profs. Werner and Bamberger, has accepted a position as research associate in biochemistry in the Graduate School of Yale University. Dr. Bandisch will affiliate with the department of chemistry and co-operate with Prof. T. B. Johnson in the promotion of biochemical research.

EINAR CHRISTENSEN has recently been placed in charge of the chemical developments of the Cinder Products Corporation, Rochester, N. Y., a new corporation engaged in the manufacture of building material from cinders.

HERBERT G. CLOPPER, formerly with the New Jersey Zinc Co. and more recently vice-president of the Eagle-Picher Lead Co., has become president and treasurer of the Multiple Storage Battery Co., Jamaica, L. I.

DALTON M. GOETSCHIUS, who was engaged by B. F. Drakenfeld & Co., Inc., to take charge of its plant at Washington, Pa., will continue his research and experimental work on radium extraction for the Standard Chemical Co. Howard B. Goetschius has taken over the management of the Drakenfeld plant.

Prof. F. GOWLAND HOPKINS of Cambridge University, England, addressed the graduate students of Yale University on the afternoon of April 4, 1921.

M. E. KESSLER has resigned from the chemical staff of the Niagara Alkali Co., and is now associated with the Waste Products Co., Niagara Falls, N. Y.

Dr. PAUL E. KLOPSTEG, who has been connected with the sales and advertising department of Leeds & Northrup for several years, has recently accepted a position with the Central Scientific Co. of Chicago, as manager of development and manufacturing.

H. M. MINER has been appointed New York representative of the Cleveland Cliffs Iron Co., Cleveland, Ohio, producer of methanol and wood chemicals.

O. E. RUHOFF, formerly chemical engineer for the French Battery & Carbon Co. of Madison, Wis., has severed his connection with this company in order to associate himself with the Industrial Research Laboratories of Chicago.

DAVID T. SCHULTZ has left his position as chemist in charge of the analytical laboratories of the Atlantic Refining Co. to become chief chemist of the New England Oil Refining Co., Fall River, Mass.

ARTHUR C. TRASK has resigned as vice-president of the Marden, Orth & Hastings Co., Inc., to become vice-president of the Falk Co., Pittsburgh, Pa., which company plans to equip a plant at Carnegie, Pa., for the refining of menhaden fish oil and for the sulphonating and processing of oils.

Obituary

CHARLES S. HAWES, in charge of the Bureau of Research and Statistics of the War Trade Board Section of the Department of State, died suddenly on Friday, April 22, in Chicago, Ill., where he was on a special investigation for the department. Death was due apparently to apoplexy and occurred at the home of Philip O. Palmer. He is survived by his wife, Mrs. Frances Wilson Hawes.

New Jersey Ceramic Exposition

The Newark, N. J., Society of Ceramic Arts held its annual exhibition at the Free Public Library during the week of April 18-23. The display was arranged on the fourth floor in the museum department and presented many interesting exhibits. Luster ware was rather the predominating feature, and there were fewer examples of delicate china and porcelain than in previous years. The exhibit showed many attractive specimens of pottery of the more substantial varieties.

Air Reduction Co. Acquires National Carbide Corp.

On May 1 the Air Reduction Co., New York, manufacturer of oxy-acetylene cutting and welding apparatus, took over the control of the National Carbide Corporation of Virginia, and in the future will direct the operating policy and sales of the organization. The acquired company's plant at Ivanhoe, Va., will be continued in operation for the production of carbide. This location has proved decidedly advantageous with regard to low costs for water power, coke and lime, as used at the works. With this acquisition, the purchasing company is in direct control of all materials and equipment entering into the production of its specialties.

Current Market Reports

Chemical and Allied Industrial Markets

NEW YORK, May 2, 1921.

Weakness is still evident in the chemical market and inquiries have not changed in character to any unusual degree during the past week. The turn in the stock market has been taken as a hopeful sign by factors in heavy chemicals and while no actual increase in buying has been noted there seems to be a general feeling of optimism throughout the trade. Conservatism is the keynote among buyers. There was a fairly active demand for light and dense *soda ash* in carload lots and producers have placed considerable business because the spot market has been practically sold out and second hands have not been in a favorable position to force keen competition with the manufacturers. In some quarters, however, there was some shading on contracts for the light soda ash and business has been booked at $1.62½ per 100 lb., basis 48 per cent, f.o.b. works, in single bags, instead of $1.72½. Competition of English producers of ash is attracting attention in the American market. There has been a large tonnage sold at $1.90 per 100 lb. laid down in N. Y. Contracts on *caustic soda* have been offered at 3½c. per lb., basis 60 per cent, f.o.b. works for prompt and future shipments, with sales recorded a shade under this quotation. The demand for caustic has not been as active as that for ash. At any rate, spot prices have been generally maintained. First-hand sales of caustic have been made at 3⅜c. per lb., basis 60 per cent, f.o.b. works. Spot lots of *bichromate of soda* have brought 7⅜c. per lb. Buyers have not been eager to pay this price, but holders of resale goods have remained firm in their views. *Bleaching powder* has developed an easier tendency and prominent sellers have sold at 2¼c. per lb. in large drums. There was moderate trading at this figure and the inquiry has been of fair dimensions all week. There has been a strong evidence of German competition reflected in *caustic potash*. This material is offered so far below the American figures that competition is practically out of the question for the present. Sellers of the 88-92 per cent caustic potash stated that offers for shipment have been heard as low as 4½c. per lb. Resale lots on spot have sold down to 5¼c. per lb. German *chlorate of potash* has been offered for shipment at 6c. per lb. These disturbing influences are sufficient to cause a cautious attitude among buyers. In the face of all this cut-throat competition the need of a protective tariff is readily seen

unless American producers accept the inevitable and close their plants. It seems that this is the desire of German producers who are bent on controlling the chemical market. There is no doubt that if the American manufacturer were abolished no such prices as the present would be named. The outlook for prices is very uncertain and will remain so until the new tariff schedule becomes effective. Many authorities in the chemical market are of the opinion that we will not experience anything approaching a general revival of business until next fall.

Chemicals

Prices in *alum* have remained practically unchanged on routine trading. *Ammonia alum* prices are based on 4@4¼c. per lb. for the lump. *Potash alum* is quoted on the basis of 5@5½c. per lb. *Ammonia chrome alum* is quoted at 13@14c. per lb. Price cutting in *bleaching powder* is widespread among holders of any sizable stocks and quotations of $2.40@$2.50 per 100 lb. is subject to considerable shading. Makers are holding for $2.75 at the works. Rumors of prices as low as $2.10 f.o.b. works could not be confirmed, but from the weak tone of the market these prices are not considered out of line. Prices on *copper sulphate* are quoted at 5¼@6c. per lb., according to makers and quantity. The market has been somewhat weaker, but first hands are not inclined to force business by any price cutting. Scattered transactions in resale *bichromate of potash* were reported at 11½c. per lb. on spot. Dealers quoted the market at 11½@12c. Demand has not shown much activity during the week and the situation remained rather quiet. A further reduction on *permanganate of potash* brought the price down to 32@35c. per lb. Limited supplies of *yellow prussiate of potash* are holding the spot market steady and sellers are not eager to shade 26c. per lb., with some asking up to 27c. for small quantities. The red variety has remained quiet, with sellers quoting from 35@40c. per lb. Prominent sellers of prime *muriate of potash* quoted $50 per ton, basis 80 per cent, delivered. A fair inquiry is reported for this chemical and transactions of large and small quantities have been recently booked. Leading factors of *chlorate of soda* have reduced the price to 7½c. per lb., f.o.b. works, for prompt shipment. This is the lowest price heard for domestic chlorate since before the war.

Spot prices for light *soda ash* in single bags are heard from $2@$2.10 per 100 lb. Resale offerings continued small and the market is reported steady in most quarters. Prominent dealers reported sales of *caustic soda* at 3¾c. per lb. ex-store N. Y. The market while quiet looks steady, although it is admitted that odd lots can be purchased below this price. Resale goods f.a.s. steamer were quoted up to $3.85@$3.90 per 100 lb. Producers report sales at 3⅜@3½c. per lb., basis 60 per cent, f.o.b. works, depending on quantity. The recent advance of *sodium nitrate* by importers has reflected itself by a further strengthening of the resale market. Resale nitrate is quoted at $2.70@$2.80 per 100 lb. on a very strong basis against an importers' price of $3. Prices on *sodium nitrite* are slightly firmer following the restriction of imports by the war trade board. Some holders have been attempting to buy up large stocks so that openly quoted prices are around 5⅝c. per lb. for spot material. Consumers, in general, have not shown any unusual interest.

Coal-Tar Products

The promise of early legislation looking toward a policy following along protective lines has created a better feeling in many quarters of the coal-tar products market and the tone throughout the week has appeared to be of a more hopeful nature. The period of waiting is surely growing shorter and definite action of some sort will put a stop to hesitancy. Fluctuations in intermediates have been narrow as far as producers' figures are concerned and second hands as well are steadier in their views. *Aniline oil* seems to show about the widest range of quotations, while *paranitraniline* and *beta naphthol* show a firmer tendency. The crude market does not show a very uniform volume of trading in the different products and while *naphthalene* and *benzene* are moving in a steadier manner other items are quiet and weak.

Prices on *benzene* quoted by refiners are held steady. Prices are quoted at 27@32c. per gal. for pure benzene in tank cars and drums. The 90 per cent grade is quoted at 25@28c. per gal. on the same basis. Buying in both grades has been of somewhat limited nature. Prices on *naphthalene* are unchanged, with the demand rated fair. Refiners are quoting 8½@9½c. per lb. for the flake and 9½@10½c. for the balls, according to quantity. Resale flake can still be had in some quarters as low as 8c. per lb. Prices on *phenol* are unchanged at recent levels with little demand noted. Quotations in the open market are around 10c. per lb., but stocks are light. Government surplus phenol is still to be had at 12c. per lb., according to quantity.

Resale *aniline oil* can be had around 19c. per lb. in fair quantity, but the quality of material at the low figure is very doubtful. Makers are offering goods as low as 20@28c. per lb., and those naming the lower figures are finding business in fair volume. Consumers are interested only in small lots for immediate requirements and in many cases are preferring to use the inferior grade offered on the spot. Prices for spot *beta naphthol* are very uncertain. Demand has been desultory and few orders of reasonable size have been booked. Resellers are generally quoting around 34c. per lb. with a variation of a few cents either way. Bids at 28c. per lb. have failed to bring out any stocks. Manufacturers are quoting unchanged prices at 40@42c. per lb., but report little interest at this level. Buyers are not inclined to increase holdings beyond immediate requirements. Quotations on *dimethylaniline* are around former levels, with 48c. per lb. quoted by resellers and 55c. quoted by makers. The resale market is subject to shading on firm business.

Vegetable Oils

Trading during the week in *castor oil* was inactive, but producers maintained prices on the basis of 10c. per lb. for the U.S.P. No. 1 and 9½c. per lb. for the No. 3 in barrels. Outside lots were available at slight concessions. The spot market for *chinawood oil* closed steady at 10c. per lb., while nearby material could be purchased at 9½c. The coast market for April-May shipment was nominal at 8½c. per lb. A good volume of business in *coconut oil* was placed during the week and prices were somewhat firmer. Some lots of Ceylon type oil sold locally on the basis of 9c. per lb. in drums. One lot of Ceylon type oil was offered during the week for immediate delivery at 9½c. per lb. Cochin quality oil was offered in some quarters on the basis of 10½c. per lb. in barrels, but several holders continued to quote the market at 11c. The production of *corn oil* has been augmented, but offerings are not pressing on the market and prices held on a steady basis. Crude oil locally was nominally unchanged at 7¾c. per lb. Refined oil held at 9¾@10c. per lb. for carlots in barrels. *Lagos palm oil* for spot delivery was firmer, the market closing at 7¼@7¾c. per lb., according to seller and quantity. On forward business there were offerings of 7c. per lb., with possible shading on firm orders. *Niger oil* was available at less than 6c. per lb., due to the presence of some distressed lots. Business was noted in crude domestic *peanut oil* at 5½c. per lb., buyers' tanks, f.o.b. mill. Some holders of crude oil advanced their prices to 5¾c. and in some instances to 6c. per lb., but buyers showed no interest in the higher quotations. English refined *rapeseed oil* was offered on the spot at 91c. per gal. On nearby oil 88c. was possible to be done, with futures available on the basis of 86c. per gal. The market on *soya bean oil* for immediate shipment from the coast held around 5c. per lb. On futures 4¼c. represented the nominal quotation, with no buying interest noted on account of the tariff situation.

The Iron and Steel Market

Pittsburgh, April 29, 1921.

The volume of strictly new buying in steel products has been particularly light in the past week, this being a natural sequence to the price changes that occurred a fortnight and more ago. As the independents advanced their prices at that time buyers had an opportunity to close on quotations then outstanding, and thus a considerable volume of business was rounded up, the buyers having correspondingly less occasion to buy now, while the advance in prices

to such buyers is also a factor. As to the Steel Corporation, whose price change was a reduction, it is receiving specifications against old contracts at a somewhat heavier rate, though on the whole the increase does not seem to be as great as might have been expected.

The quantity of steel consumption has plainly not been affected one way or the other. If the present rate of consumption is equal to the rate of production, it is probably as great a rate as can reasonably be expected under present financial and industrial conditions generally, for the rate is nearly if not quite 40 per cent of capacity. The rate of production during the first nine months of 1920, when the appearance was of heavy consumption and an almost insatiable demand, was approximately 80 per cent of capacity. Comparing general conditions, one would not expect there to be more than one-half as much steel consumption now.

A test of the lightness of steel demand in general is the prominence that is given in trade circles to the steel requirements of the automobile trade, when it is known that the manufacture of automobiles did not consume more than about 5 per cent of the steel production in 1920 and the automobile industry cannot be expected to have nearly as large a production this year as it had last year.

PRICES

Finished steel prices remain quotable as follows: Bars, 2.10c.; shapes, 2.20c.; plates, 2.20c.; hoops, 2.75c.; plain wire, 3c.; wire nails, \$3.25; standard steel pipe, 62½ per cent basing discount; blue annealed sheets, 3.10c.; black sheets, 4c.; galvanized sheets, 5c.; tin plate, \$6.25.

There has been another revision in spike prices. The separate prices on standard spikes, small spikes and boat spikes named in this report a week ago have been withdrawn, and a single base price of 3.40c. has been substituted, this being a reversion to practice before the war, there being extras over the base price for small spikes and the various sizes of boat and barge spikes. The reduction in chain from 6.75c. to 6.35c. by one manufacturer has been followed by a reduction to 6.25c. by others, as a base price, while spreads on sizes ½ in. and smaller were decreased by ¼c.

Some question is already being raised whether the new prices on rolled steel products are being strictly maintained. Cases of apparent shading are usually attributed to "old quotations," though this may be really a sort of subterfuge. Strictly new demand is too light to give the market much of a test, requisitions being chiefly in the form of specifications against old contracts or of releases on orders previously suspended.

PIG IRON AND COKE

The stiffening in the independent market in steel products has not been reflected in any increased strength in pig iron or coke. Thus there is no general stiffening tendency in the iron and steel industry as a whole, the recent operation being simply one of equalization between the Steel Corporation and independent prices for steel products. Foundry iron, formerly quotable at \$25 valley, is being offered at \$24.50 by at least one merchant furnace. Basic iron has again been sold by a steel works interest at \$22.50, the nominal market quotation being \$23, while a quotation of \$22 is understood to have been made to the United Alloy Steel Corporation, which, however, has decided to blow in its furnace and make its iron itself, having the advantage of a byproduct coking plant, for which coal has just been bought.

As to Connellsville coke, which appeared recently to be established at \$3.50, it has sold at \$3.25, and in some quarters there are predictions that the next important sale will be at \$3.

The opening of sales of Lake Superior iron ore for the shipping season of 1921 appears to be no nearer than three months ago. Estimates of the tonnage of ore to be moved this year are still lower, and nearly all the estimated ore will be moved by the producer-consumer class. Early predictions were that there would be a reduction of \$1 a ton from the 1920 schedule, which set Mesabi non-bessemer at \$6.55. That would represent a restoration of the 1919 schedule, but the prospect now is that the reduction will be somewhat greater.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..... -	\$0.40 - \$0.45
Acetone	lb.	\$0.13 - \$0.13½	.13¾ - .14
Acid, acetic, 28 per cent	100 lbs.	2.50 - 2.75	3.00 - 3.25
Acetic, 56 per cent	100 lbs.	4.00 - 4.25	4.50 - 5.50
Acetic, glacial, 99½ per cent, carboys,	100 lbs.	9.50 - 9.75	10.00 - 10.50
Boric, crystals	lb.	.13½ - .14	.14½ - .15
Boric, powder	lb.	.15 - .15½	.16 - .16½
Citric	lb.	..... -	.46 - .47
Hydrochloric	100 lb.	1.50 - 1.65	1.75 - 2.00
Hydrofluoric, 52 per cent	lb.	.13 - .13½	.14 - .14½
Lactic, 44 per cent tech	lb.	.10 - .11	.11½ - .12
Lactic, 22 per cent tech	lb.	.04½ - .05½	.06 - .07
Molybdic, C. P.	lb.	4.00 - 4.50	4.50 - 5.00
Muriatic, 20 deg. (see hydrochloric)		..... -	..... - .....
Nitric, 40 deg	lb.	.06½ - .06¾	.07 - .07½
Nitric, 42 deg	lb.	.07¼ - .07½	.07¾ - .08¼
Oxalic, crystals	lb.	.17 - .18	.18½ - .20
Phosphoric, Ortho, 50 per cent solution	lb.	.17 - .17½	.18 - .19
Picric	lb.	.30 - .32	.35 - .40
Pyrogallic, resublimed	lb.	..... -	1.90 - 2.15
Sulphuric, 60 deg., tank cars	ton	..... -	12.00 - 13.00
Sulphuric, 60 deg., drums	ton	..... -	14.00 - 15.00
Sulphuric, 66 deg., tank cars	ton	19.00 - 20.00	..... - .....
Sulphuric, 66 deg., drums	ton	22.00 - 22.50	23.00 - 23.50
Sulphuric, 66 deg., carboys	ton	..... -	..... - .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	23.00 - 24.00	..... - .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	25.00 - 26.00	26.50 - 27.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 - 35.00	40.00 - .....
Tannic, U. S. P.	lb.	..... -	1.00 - 1.10
Tannic (tech.)	lb.	.50 - .52	.54 - .57
Tartaric, crystals	lb.	..... -	.35 - .39
Tungstic, per lb. of WO	lb.	..... -	1.30 - 1.40
Alcohol, Ethyl	gal.	..... -	4.75 - 5.25
Alcohol, Methyl (see methanol)		..... -	..... - .....
Alcohol, denatured, 188 proof	gal.	..... -	.34 - .36
Alcohol, denatured, 190 proof	gal.	..... -	.40 - .45
Alum, ammonia lump	lb.	.04 - .04¼	.04½ - .04¾
Alum, potash lump	lb.	.05 - .05¾	.05¾ - .06½
Alum, chrome lump	lb.	.13 - .13½	.14 - .14½
Aluminum sulphate, commercial	lb.	.02¼ - .02½	.02¾ - .03
Aluminum sulphate, iron free	lb.	.03¼ - .03½	.03¾ - .04¼
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07 - .07½	.07¾ - .08
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 - .32	.33 - .35
Ammonium carbonate, powder	lb.	.07½ - .08	.08½ - .10
Ammonium chloride, granular (white salamoniac) (nominal)	lb.	.06½ - .06¾	.07 - .07½
Ammonium chloride, granular (gray salammoniac)	lb.	.08½ - .08¾	.09 - .09½
Ammonium nitrate	lb.	.08 - .08½	.09 - .10
Ammonium sulphate	100 lb.	2.75 - 2.85	2.90 - 3.00
Amylacetate	gal	..... -	4.00 - 4.25
Amylacetate tech	gal	..... -	3.00 - 3.25
Arsenic oxide, (white arsenic) powdered	lb.	.07¾ - .08	.08¼ - .09
Arsenic, sulphide, powdered (red arsenic)	lb.	.12 - .12½	.13 - .14
Barium chloride	ton	60.00 - 65.00	70.00 - 75.00
Barium dioxide (peroxide)	lb.	.19 - .20	.21 - .22
Barium nitrate	lb.	.11 - .11½	.12 - .12½
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ - .05	.05½ - .06
Bleaching powder (see calc. hypochlorite)		..... -	..... - .....
Blue vitriol (see copper sulphate)		..... -	..... - .....
Borax (see sodium borate)		..... -	..... - .....
Brimstone (see sulphur, roll)		..... -	..... - .....
Bromine	lb.	.40 - .41	.42 - .45
Calcium acetate	100 lbs.	1.90 - 2.00	..... - .....
Calcium carbide	lb.	.04¾ - .05	.05 - .05½
Calcium chloride, fused, lump	ton	27.00 - 29.00	30.00 - 32.00
Calcium chloride, granulated	lb.	.01½ - .01¾	.02 - .02½
Calcium hypochlorite (bleach'g powder)	100 lb.	2.25 - 2.40	2.50 - 2.75
Calcium peroxide	lb.	..... -	1.25 - 1.50
Calcium phosphate, tribasic	lb.	..... -	.15 - .16
Camphor	lb.	..... -	.61 - .63
Carbon bisulphide	lb.	.07 - .07½	.07½ - .08
Carbon tetrachloride, drums	lb.	.10 - .10½	.11 - .12
Carbonyl chloride (phosgene)	lb.	..... -	.75 - 1.00
Caustic potash (see potassium hydroxide)		..... -	..... - .....
Caustic soda (see sodium hydroxide)		..... -	..... - .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.08 - .09	.09½ - .10
Chloroform	lb.	..... -	.38 - .40
Cobalt oxide	lb.	..... -	3.00 - 3.10
Copperas (see iron sulphate)		..... -	..... - .....
Copper carbonate, green precipitate	lb.	.23 - .24	.25 - .27
Copper cyanide	lb.	..... -	.50 - .62
Copper sulphate, crystals	lb.	.05¼ - .05½	.05¾ - .06
Cream of tartar (see potassium bitartrate)		..... -	..... - .....
Epsom salt (see magnesium sulphate)		..... -	..... - .....
Ethyl Acetate Com. 85%	gal.	..... -	.90 - 1.00
Ethyl Acetate pure (acetic ether 98% to 100%)		..... -	..... - .....
Formaldehyde, 40 per cent	lb.	.14 - .14¼	.14½ - .15
Fusel oil, ref	gal.	..... -	3.25 - 3.50
Fusel oil, crude	gal.	..... -	1.75 - 2.00
Glauber's salt (see sodium sulphate)		..... -	..... - .....
Glycerine, C. P. drums extra	lb.	..... -	.17 - .17½
Iodine, resublimed	lb.	..... -	3.75 - 3.85
Iron oxide, red	lb.	..... -	.10 - .20
Iron sulphate (copperas)	100 lb.	.75 - 1.00	1.10 - 1.25
Lead acetate,	lb.	..... -	.11¾ - .13½
Lead arsenate, paste	lb.	.08½ - .09	.09½ - .10
Lead nitrate	lb.	..... -	.15 - .20
Litharge	lb.	.08¾ - .09	.09½ - .10
Lithium carbonate	lb.	..... -	1.25 - .....
Magnesium carbonate, technical	lb.	.10½ - .11	.11½ - .12
Magnesium sulphate, U. S. P.	100 lb.	2.75 - 3.00	..... - .....
Magnesium sulphate, technical	100 lb.	..... -	1.40 - 2.25
Methanol, 95%	gal.	..... -	.75 - .77
Methanol, 97%	gal.	..... -	.78 - .82
Nickel salt, double	lb.	..... -	.13 - .13½
Nickel salt, single	lb.	..... -	.14 - .14½
Phosgene (see carbonyl chloride)		..... -	..... - .....
Phosphorus, red	lb.	.45 - .46	.47 - .50
Phosphorus, yellow	lb.	..... -	.35 - .37
Potassium bichromate	lb.	.11½ - .11¾	.12 - .12½

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$ ... – $....	$0.30 – $0.35
Potassium bromide, granular	lb.	..... –	.20 – .40
Potassium carbonate, U. S. P.	lb.	.35 – .40	.45 – .50
Potassium carbonate, crude	lb.	.06½ – .07	.08 – .09
Potassium chlorate, crystals	lb.	.08 – .09	.10 – .14
Porassium cyanide	lb.	..... –	.30 – .32
Potassium hydroxide (caustic potash)	lb.	.05½ – .06	.06½ – .08
Potassium muriate	ton	50.00 – 50.50	– ....
Potassium iodide	lb.	..... –	2.75 – 3.00
Potassium nitrate	lb.	.09¼ – .09½	.10 – .12¾
Potassium permanganate	lb.	.32 – .33	.34 – .35
Potassium prussiate, red	lb.	.35 – .37	.38 – .40
Potassium prussiate, yellow	lb.	.26 – .27	.28 – .29
Potassium sulphate (powdered)	per unit	..... –	1.75 – 1.80
Rochelle salts (see sodium potas. tartrate)	....	....	..... – .....
Salammoniac (see ammonium chloride)	....	....	..... – .....
Sal soda (see sodium carbonate)	....	..... –	..... – .....
Salt cake	ton	..... –	33.00 – 35.00
Silver cyanide	oz.	..... –	1.30 – 1.35
Silver nitrate	oz.	..... –	.39 – .40
Soda ash, light	100 lb.	2.00 – 2.10	2.20 – 2.40
Soda ash, dense	100 lb.	2.30 – 2.35	2.40 – 2.60
Sodium acetate	lb.	.04¾ – .05	.05½ – .06
Sodium bicarbonate	100 lb.	2.50 – 2.60	2.70 – 3.00
Sodium bichromate	lb.	.07¾ – .08	.08¼ – .08½
Sodium bisulphate (nitre cake)	ton	5.00 – 5.25	5.50 – 6.50
Sodium bisulphite powdered, U.S.P.	lb.	.05¼ – .05½	.05¾ – .06¼
Sodium borate (borax)	lb.	.06½ – .06¾	.07 – .07¼
Sodium carbonate (sal soda)	100 lb.	1.90 – 2.00	2.25 – 2.50
Sodium chlorate	lb.	.07¾ – .08	.08¼ – .08½
Sodium cyanide, 96-98 per cent	lb.	.20 – .22	.23 – .30
Sodium fluoride	lb.	.12 – .12½	.13 – .14
Sodium hydroxide (caustic soda)	100 lb.	3.65 – 3.75	3.80 – 4.00
Sodium hyposulphite	,	..... –	.03¾ – .04
Sodium nitrate	100 lb.	2.75 –	2.85 – ....
Sodium nitrite	lb.	.05¾ – .06	.06¼ – .07
Sodium peroxide, powdered	lb.	.25 – .26	.27 – .30
Sodium phosphate, dibasic	lb.	.04½ – .04¾	.05 – .05½
Sodium potassium tartrate (Rochelle salts)	lb.	..... –	.27 – .28
Sodium prussiate, yellow	lb.	.11½ – .11¾	.12 – .12½
Sodium silicate, solution (40 deg.)	lb.	1.25 – 1.35	1.40 – 1.50
Sodium silicate, solution (60 deg.)	lb.	.02¾ – .03	.03¼ – .03¾
Sodium sulphate, crystals (Glauber's salt)	100 lbs.	1.50 – 1.75	2.00 – 2.25
Sodium sulphide, fused, 60-62 per cent (conc.)	lb.	.05¼ – .05¾	.06 – .06½
Sodium sulphite, crystals	lb.	.03¾ – .04	.04¼ – .04½
Strontium nitrate, powdered	lb.	.16 – .16½	.17 – .18
Sulphur chloride, red	lb.	.07 – .07¼	.07½ – .08
Sulphur, crude	ton	20.00 – 22.00	..... – .....
Sulphur dioxide, liquid, cylinders extra	lb.	.08 – .08½	.09 – .10
Sulphur (sublimed), flour	100 lb.	..... –	2.25 – 3.10
Sulphur, roll (brimstone)	100 lb.	..... –	2.00 – 2.75
Tin bichloride, 50 per cent	lb.	.18 – .19	..... – .....
Tin oxide	lb.	..... –	.40 – .42
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran	lb.	.11 – .11¼	.11½ – .12
Zinc cyanide	lb.	.45 – .49	.50 – .60
Zinc dust	lb.	.12 – .13	.13½ – .14
Zinc oxide, XX	lb.	.08½ – .09	.09½ – .10
Zinc sulphate	lb.	.03¼ – .03½	.04 – .05

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.10 —	$1.15
Alpha-naphthol, refined	lb.	1.25 —	1.30
Alpha-naphthylamine	lb.	.35 —	.40
Aniline oil, drums extra	lb.	.20 —	.26
Aniline salts	lb.	.26 —	.29
Anthracene, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde U.S.P.	lb.	1.00 —	1.50
Benzidine, base	lb.	.90 —	1.00
Benzidine sulphate	lb.	.75 —	.80
Benzoic acid, U.S.P.	lb.	.65 —	.70
Benzoate of soda, U.S.P.	lb.	.65 —	.70
Benzene, pure, water-white, in drums (100 gal.)	gal.	.27 —	.32
Benzene, 90%, in drums (100 gal.)	gal.	.25 —	.28
Benzyl chloride, 95-97%, refined	lb.	.28 —	.30
Benzyl chloride, tech	lb.	.25 —	.27
Beta-naphthol benzoate	lb.	3.50 —	4.00
Beta-naphthol, sublimed	lb.	.70 —	.75
Beta-naphthol, tech	lb.	.33 —	.45
Beta-naphthylamine, sublimed	lb.	2.00 —	2.25
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.25 —	.27
Cresylic acid, 97-99%, straw color, in drums	gal.	.90 —	.95
Cresylic acid, 95-97%, dark, in drums	gal.	.85 —	.90
Cresylic acid, 50%, first quality, drums	gal.	.55 —	.60
Dichlorbenzene	lb.	.06 —	.09
Diethylaniline	lb.	1.20 —	1.25
Dimethylaniline	lb.	.48 —	.55
Dinitrobenzene	lb.	.32 —	.35
Dinitroclorbenzene	lb.	.20 —	.30
Dinitronaphthalene	lb.	.30 —	.40
Dinitrophenol	lb.	.35 —	.40
Dinitrotoluene	lb.	.25 —	.27
Dip oil, 25%, tar acids, car lots, in drums	gal.	.40 —	.45
Diphenylamine	lb.	.60 —	.70
H-acid	lb.	1.30 —	1.50
Meta-phenylenediamine	lb.	1.20 —	1.25
Monochlorbenzene	lb.	.12 —	.14
Monoethylaniline	lb.	1.75 —	1.85
Naphthalene crushed, in bbls. (250 lb.)	lb.	.08 —	.08½
Naphthalene, flake	lb.	.08½ —	.09½
Naphthalene, balls	lb.	.09½ —	.10½
Naphthionic acid, crude	lb.	.70 —	.75
Nitrobenzene	lb.	.12 —	.15
Nitro-naphthalene	lb.	.30 —	.35
Nitro-toluene	lb.	.16 —	.18
Ortho-amidophenol	lb.	3.15 —	3.40
Ortho-dichlor-benzene	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.75 —	.80
Ortho-nitro-toluene	lb.	.17 —	.20
Ortho-toluidine	lb.	.20 —	.25
Para-amidophenol, base	lb.	1.60 —	1.75
Para-amidophenol, HCl	lb.	1.75 —	1.85
Para-dichlorbenzene	lb.	.15 —	.20
Paranitroaniline	lb.	.85 —	1.05
Para-nitrotoluene	lb.	.85 —	1.00
Para-phenylenediamine	lb.	1.95 —	2.00
Para-toluidine	lb.	1.25 —	1.60
Phthalic anhydride	lb.	.50 —	.60
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.11 —	.13
Pyridine	gal.	2.00 —	3.50
Resorcinol, technical	lb.	1.75 —	1.85
Resorcinol, pure	lb.	2.25 —	2.30
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.22 —	.23
Salicylic acid, U. S. P.	lb.	.21 —	.22
Salol	lb.	.85 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 —	.28
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.14 —	.16
Sulphanilic acid, crude	lb.	.30 —	.35
Tolidine	lb.	1.35 —	1.45
Toluidine, mixed	lb.	.40 —	.45
Toluene, in tank cars	gal.	.25 —	.28
Toluene, in drums	gal.	.28 —	.31
Xylidines, drums, 100 gal.	lb.	.40 —	.45
Xylene, pure, in drums	gal.	.42 —	.45
Xylene, pure, in tank cars	gal.	.45 —	....
Xylene, commercial, in drums, 100 gal.	gal.	.33 —	.35
Xylene, commercial, in tank cars	gal.	.30 —	....

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.23 —	$0.25
Beeswax, refined, light	lb.	.25 —	.27
Beeswax, white pure	lb.	.40 —	.45
Carnauba, Flora	lb.	.62 —	.64
Carnauba, No. 2, North Country	lb.	.29 —	.30
Carnauba, No. 3, North Country	lb.	.18 —	.18½
Japan	lb.	.18½ —	.19½
Montan, crude	lb.	.07 —	.08
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.04 —	....
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.03¾ —	....
Paraffine waxes, refined, 118-120 m.p.	lb.	.04 —	.04¼
Paraffine waxes, refined, 125 m.p.	lb.	.04½ —	.04¾
Paraffine waxes, refined, 128-130 m.p.	lb.	.05 —	.05¼
Paraffine waxes, refined, 133-135 m.p.	lb.	.06 —	.06
Paraffine waxes, refined, 135-137 m.p.	lb.	.06½ —	.06¾
Stearic acid, single pressed	lb.	.09½ —	....
Stearic acid, double pressed	lb.	.10 —	....
Stearic acid, triple pressed	lb.	.11 —	.11¼

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.	280 lb.	$5.25 —	.....
Rosin E-I	280 lb.	5.35 —	.....
Rosin K-N	280 lb.	5.60 —	.....
Rosin W. G.-W. W.	280 lb.	6.50 —	.....
Wood rosin, bbl.	280 lb.	6.25 —	.....
Spirits of turpentine	gal.	.66 —	.....
Wood turpentine, steam dist.	gal.	.64 —	.....
Wood turpentine, dest. dist.	gal.	.62 —	.....
Pine tar pitch, bbl.	200 lb.	...... —	7.00
Tar, kiln burned, bbl. (500 lb.)	bbl.	...... —	12.50
Retort tar, bbl.	500 lb.	—	12.50
Rosin oil, first run	gal.	.40 —	.....
Rosin oil, second run	gal.	.44 —	.....
Rosin oil, third run	gal.	.47 —	.....
Pine oil, steam dist., sp.gr., 0.930-0.940	gal.		$1.70
Pine oil, pure, dest. dist.	gal.		1.60
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.		.48
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.		.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.		.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.		1.20
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.		.37
Pinewood creosote, ref.	gal.		.55

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.41
70-72 deg., steel bbls. (85 lb.)	gal.	.39
68-70 deg., steel bbls. (85 lb.)	gal.	.38
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.30

Crude Rubber

Para—Upriver fine	lb.	$0.17 —	.....
Upriver coarse	lb.	.11¾ —	.12½
Upriver caucho ball	lb.	.14 —	.14½
Plantation—First latex crepe	lb.	.20 —	.....
Ribbed smoked sheets	lb.	.17½ —	.....
Brown crepe, thin, clean	lb.	.18 —	.....
Amber crepe No. 1	lb.	.20 —	.....

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.09 —	$0.09½
Castor oil, AA, in bbls.	lb.	.10 —	.10¼
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.08¾ —	.09
Cocoanut oil, Ceylon grade, in bbls.	lb.	.09¾ —	.10
Cocoanut oil, Cochin grade, in bbls.	lb.	.10½ —	.11
Corn oil, crude, in bbls.	lb.	.07¾ —	.08
Cottonseed oil, crude (f. o. b. mill)	lb.	.05 —	.05¼
Cottonseed oil, summer yellow	lb.	.07 —	.07¼
Cottonseed oil, winter yellow	lb.	.07½ —	....
Linseed oil, raw, car lots (domestic)	gal.	.60 —	.61
Linseed oil, raw, tank cars (domestic)	gal.	.53 —	....
Linseed oil, in 5-bbl lots (domestic)	gal.	.63 —	.65

Olive oil, Denatured	gal	$1.40	— $1.60
Palm, Lagos	lb.	.07	— .07½
Palm, Niger	lb.	.05½	— .06
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.05½	— .05¾
Peanut oil, refined, in bbls	lb.	.10	— .10½
Rapeseed oil, refined in bbls	gal.	.90	— .92
Rapeseed oil, blown, in bbls	gal.	1.00	— 1.05
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.07¼	— .07½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.04¼	— ....

FISH

Light pressed menhaden	gal.	$0.42	— $0.43
Yellow bleached menhaden	gal.	.45	— ....
White bleached menhaden	gal.	.48	— ....
Blown menhaden	gal.	.80	— ....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$24.00	— 30.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	22.00	— 26.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00	— 1[illegible].00
Barytes, floated, f.o.b. St. Louis	net ton	26.50	— 28.00
Barytes, crude, first grade, Missouri	net ton	10.00	— ....
Blanc fixe, dry	lb.	.05	— .05½
Blanc fixe, pulp	net ton	50.00	— 60.00
Casein	lb.	.14	— .16
Chalk, domestic, extra light	lb.	.05	— .05½
Chalk, domestic, light	lb.	.04½	— .05
Chalk, domestic, heavy	lb.	.04	— .05
Chalk, English, extra light	lb.	.05	— .07
Chalk, English, light	lb.	.05	— .06
Chalk, English, dense	lb.	.04½	— .05
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	8.00	— 10.00
China clay (kaolin) washed, f.o.b. Georgia	net ton	12.00	— 15.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	18.00	— 22.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00	— 12.00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	15.00	— 40.00
China clay (kaolin), imported, lump	net ton	23.00	— 25.00
China clay (kaolin), imported, powdered	net ton	30.00	— 35.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	gross ton	8.00	— 14.00
Feldspar, crude, f.o.b. Maine	net ton	7.50	— 10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00	— 23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00	— 21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00	— 21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00	— 30.00
Fullers earth, f.o.b. Mines	net ton	16.00	— 17.00
Fullers earth, granular, f.o.b. Pa	net ton	15.00	— 25.00
Fullers earth, powdered, f.o.b. Fla	net ton	18.00	— ....
Fullers earth, imported, powdered	net ton	24.00	— 27.00
Graphite, Ceylon lump, first quality	lb.	.07½	— .08
Graphite, Ceylon chip	lb.	.06	— .06½
Graphite, high grade amorphous crude	lb.	.02¼	— .03
Pumice stone, imported, lump	lb.	.04	— .50
Pumice stone, domestic lump	lb.	.05	— .05½
Pumice stone, ground	lb.	.06	— .07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	.....	— 10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	.....	— 14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	.....	— 17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	— 7.50
Shellac, orange fine	lb.	.57	— .....
Shellac, orange superfine	lb.	.60	— .....
Shellac, A. C. garnet	lb.	.46	— .....
Shellac, T. N	lb.	.50	— .....
Soapstone	ton	12.00	— 15.00
Sodium chloride	long ton	14.00	— 15.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00	— 20.00
Talc, roofing grades, f.o.b. Vermont	ton	8.50	— 13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00	— 18.00
Talc, powdered, Southern, f.o.b. cars	ton	10.00	— 14.00
Talc, imported	ton	35.00	— 40.00
Talc, California talcum powder grade	ton	18.00	— 40.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	1,000	160
Carborundum refractory brick, 9-in. — less than carlot	1,000	1250.00
Carborundum refractory brick, 9-in. — carload lots	1,000	1100.00
Chrome brick, f.o.b. Eastern shipping points	net ton	80–100
Chrome cement, 40–45% Cr_2O_3	net ton	45–50
Chrome cement, 40–45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton	 55
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	55–60
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	45–50
Magnesite brick, 9-in. straight	net ton	90
Magnesite brick, 9-in. arches, wedges and keys	net ton	105
Magnesite brick, soaps and splits	net ton	120
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000	45–55
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000	45–55
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000	45–55

Ferro-Alloys

All f.o.b. Works

Ferro-titanium, 15-18%, f.o.b. Niagara Falls, N. Y	net ton	$200.00	— $225.00
Ferrochrome per lb. of Cr. contained, 6–8% carbon, carlots	lb.	.15	— .16
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.16	— .17
Ferromanganese, 76-80% Mn, domestic	gross ton	85.00	— 90.00
Ferromanganese, 76-80% Mn, English	gross ton	85.00	— 90.00
Spiegeleisen, 18-22% Mn	gross ton	32.00	— 35.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb	2.50	— .....
Ferrosilicon, 10-15%	gross ton	50.00	— 55.00
Ferrosilicon, 50%	gross ton	80.00	— 85.00
Ferrosilicon, 75%	gross ton	145.00	— 150.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.45	— .50
Ferrouranium, 35-50% of U, per lb. of U content	lb.	6.00	— .....
Ferrovanadium, 30-40% per lb. of contained V	lb.	5.00	— 6.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	gross ton	$8.00	— $10.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	unit	.45	— .50
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	unit	.45	— .50
Coke, foundry, f.o.b. ovens	net ton	4.50	— 5.00
Coke, furnace, f.o.b. ovens	net ton	3.25	— 3.75
Coke, petroleum, refinery, Atlantic seaboard	net ton	15.00	— 16.00
Fluorspar, lump, f.o.b. Heathden, New Mexico	net ton	17.50	— .....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00	— 22.50
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01¼	— .01½
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	.25	— .30
Manganese ore, chemical (MnO_2)	gross ton	60.00	— 65.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.55	— .60
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	30.00	— .....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.14	— .14
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.14	— .14
Pyrites, domestic, fines, f.o.b. mines, Ga	unit	.12	— .13
Rutile, 95% TiO_2 per lb. ore	lb.	.15	— .....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	3.00	— 3.25
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	3.00	— 3.25
Uranium ore (carnotite) per lb. of U_3O_8	lb.	1.50	— 2.50
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.25	— 2.50
Vanadium pentoxide, 99%	lb.	12.00	— 14.00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1.50	— .....
Zircon, washed, iron free	lb.	.03	— .....

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	12.50@12.75
Aluminum, 98 to 99 per cent	28.0@28.5
Antimony, wholesale lots, Chinese and Japanese	5¼@5½
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Monel metal, spot and blocks	0.35
Monel metal ingots	0.38
Monel metal, sheet bars	0.40
Tin, 5-ton lots, Straits	31.50
Lead, New York, spot	4.35@4.50
Lead, E. St. Louis, spot	4.35
Zinc, spot, New York	5.50
Zinc, spot, E. St. Louis	5.00

OTHER METALS

Silver (commercial)	oz.	$.60¾
Cadmium	lb.	1.00–1.10
Bismuth (500 lb. lots)	lb.	1.50@1.65
Cobalt	lb.	4.00
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	72.00–75.00
Iridium	oz.	250.00@300.00
Palladium	oz.	65.00@70.00
Mercury	75 lb.	45.00–46.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	20.50–20.75
Copper bottoms	28.00–28.25
Copper rods	19.25–20.00
High brass wire	18.25
High brass rods	15.25
Low brass wire	20.25
Low brass rods	20.25
Brazed brass tubing	29.00
Brazed bronze tubing	34.25
Seamless copper tubing	22.00
Seamless high brass tubing	21.00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York — Current	New York — One Year Ago	Cleveland	Chicago
Copper, heavy and crucible	8.50@9.00	18.50	10.00	10.50
Copper, heavy and wire	8.00@8.25	16.50	9.50	9.50
Copper, light and bottoms	7.00@7.50	14.50	9.00	8.50
Lead, heavy	3.25@3.50	7.25	4.00	4.00
Lead, tea	2.15@2.30	5.25	3.00	3.00
Brass, heavy	4.25@4.50	9.50	7.00	10.00
Brass, light	3.00@3.25	8.00	5.00	5.50
No. 1 yellow brass turnings	4.00@4.25	9.50	5.50	6.00
Zinc	2.00@2.50	5.00	3.00	3.50

Structural Material

The following base prices per 100 lb. aref or structural shapes 3 in. by ¼ in. and arger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	$2.50	$3.23	$3.23
Soft steel bars	2.50	3.00	3.13
Soft steel bar shapes	2.50	3.13	3.13
Soft steel bands	2.85	3.83	3.83
Plates, ¼ to 1 in. thick	2.50	3.30	3.30

*Add 10c per 100 lb. for trucking to Jersey City and 15c for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

ANNISTON.—The Alabama Mica & Mfg. Co., recently organized, is planning for the erection of a new local plant for the reduction and grinding of mica. A portion of the works will be devoted to the manufacture of mica products. The company has a large tract of mica lands in Randolph Co., which will be developed for raw material supply. Harry H. Wand, Chattanooga, Tenn., is president; A. Albert Tapley, Heflin, Ala., is treasurer.

ALABAMA CITY.—The Birmingham Slag Co., Birmingham, Ala., is considering plans for the erection of a new plant for the manufacture of brick and tile products.

Arkansas

EL DORADO.—The El Dorado Refining Co., Texarkana, Tex., recently organized, is considering the erection of a new plant in the vicinity of El Dorado, with initial capacity of about 5,000 bbl. W. H. Locker, Duluth, Minn., is president.

MENA.—The Cooper Mining & Development Co., Cooper, Tex., is planning for the construction of a manganese ore development plant in the vicinity of Mena. The company has a large tract of property in this section.

EL DORADO.—The Constantin Oil & Refining Co. is reported to be planning for extensions and improvements in its plant, including the installation of a new oil refinery. The work is estimated to cost in excess of $500,000.

Georgia

ATLANTA.—The Morgan Chemical Co., Ogdensburg, N. Y., is reported to be planning for the construction of a new plant in the vicinity of Atlanta, to cost about $1,000,000 with machinery. The factory will be devoted to the manufacture of insectides and other chemical specialties. E. R. Harriman is president.

Indiana

ELKHART. — The American Coating Mills, manufacturer of enameled paper products, is taking bids for the erection of a new 3-story plant at the foot of Division St. It will be known as Plant No. 2, and is estimated to cost about $300,000 with machinery. James L. Carey, 208 North Laramie Ave., Chicago, Ill., is engineer. C. C. Colburt is president.

Kansas

KANSAS CITY.—The Kansas City Foundry Co., manufacturer of small iron castings, etc., has taken bids for the erection of a new 1-story foundry, 65 x 130 ft., at Water and Walker Sts. E. C. Austin is secretary.

Kentucky

ASHLAND.—The Olive Hill Refractories Co., recently organized, is planning for the construction of a new plant at Olive Hill, Ky., for the manufacture of firebrick and other refractory products. The initial plant will have a capacity of about 30,000 bricks per day. John F. Hager is president and J. William Stewart treasurer.

LOUISVILLE.—The Dixie Belle Refining Co., 105 Inter-Southern Bldg., will soon award the contract for its proposed new oil refinery, estimated to cost about $500,000 with machinery. The company was organized recently with a capital of $650,000. G. H. Murphy is president. Carl B. Haun, Blackwell, Okla., is engineer for the project.

Louisiana

NEW ORLEANS.—The J. S. Long Co. is planning for the erection of a new 1-story plant, 100 x 300 ft., to be equipped for the manufacture of soap products.

Massachusetts

AMHERST.—The Massachusetts Agricultural College is having plans prepared for the construction of a new chemical laboratory at the institution to cost about $125,000. J. H. Ritchie and G. E. Jonesburg, 15 Ashburton Pl., Boston, Mass., are architects.

Maryland

SILVERHILL.—The Silverhill Sand & Cement Products Co., recently organized, has plans under way for the construction of a new plant for the manufacture of tile, sills, steps and other cement products for structural service. Three 1-story buildings will be erected. John Campbell is president and Frank Bell manager.

Michigan

ST. JOSEPH.—The Fay Foundry Co., manufacturer of iron and brass castings, etc., has awarded a general contract to Max Stock & Sons, Benton Harbor, Mich., for the erection of a 1-story foundry addition to cost about $25,000. John Fay is president.

Minnesota

ST. PAUL.—The Northwestern Spring Mfg. Co., 3720 University Ave., N. E., has awarded a contract to P. C. Giguere, Minneapolis, for the rebuilding of its spring manufacturing plant in the Columbia Heights section, 2-story, recently destroyed by fire. The new plant will cost about $100,000. J. W. Hines is head.

Missouri

KANSAS CITY.—The Husted Syndicate Oil Co., 16th St. and Cookson Ave., is planning for the rebuilding of the portion of its oil refinery, destroyed by fire, April 14, with loss of about $25,000.

Montana

BILLINGS.—The Montana Refining Co. is planning for the construction of a new oil refinery with initial capacity of about 1,000 bbl. The plant is estimated to cost about $125,000. The company is capitalized at $500,000. Rudolph Molt is president.

New Jersey

NEW BRUNSWICK.—The Department of Ceramics, Rutgers College, has made a list of machinery and equipment to be installed in the new ceramic school building and will make purchases at an early date. Bids for the new school will be taken at once. It is estimated to cost about $100,000, and a state appropriation for this amount has been granted. George H. Brown is director of the department.

BAYONNE.—The Standard Oil Co., 26 B'way, New York, has acquired property on East 22d St., between Ave. H and Central Ave., in the vicinity of its oil refinery, Constable Hook, Bayonne, for a consideration said to be about $270,000. Present buildings on the site will be demolished and the property used for plant extensions.

NEWARK.—The Flexible Cork Co. has leased a portion of the former plant of the Universal Caster & Foundry Co., 124-32 Adams St., for the manufacture of cork specialties. The space totals about 8,000 sq.ft., and the company will take possession about May 1. Equipment will be installed at an early date.

New York

DUNKIRK.—The Thatcher Mfg. Co., manufacturer of glassware, is planning for the erection of modern, fireproof plant to replace its factory destroyed by fire, April 19, with loss of about $100,000, including machinery. The former works comprised a number of buildings on West Second St.

NEW YORK.—The Mexican Petroleum Co., 120 B'way, has arranged for a bond issue of $10,000,000, the proceeds to be used for general operations, extensions and improvements in oil refineries, etc. The company is a subsidiary of the Pan-American Petroleum & Transport Co., same address, of which E. L. Doheny is president.

BUFFALO.—The Warner Jewelry Case Co., 682 Michigan Ave., manufacturer of cardboard and fiber containers, etc., is reported to be planning for the immediate establishment of a new local plant to replace its works destroyed by fire, April 19, with loss estimated at about $125,000.

Ohio

CANTON.—The Whitaker-Greer Fireproofing Co., manufacturer of fireproof building products, has resumed operations at full capacity at its plants at Magnolia and Waynesburg, O., following a shutdown of several months due, in part, to labor troubles.

Ontario

TRENTON.—The Chemical Products Co., Ltd., Toronto, is planning for the construction of a new acid phosphate plant at its local chemical works.

Pennsylvania

CHESTER.—The Cellulose Silk Co. of America is planning for the early installation of machinery at the local Patterson mills, recently acquired, for the manufacture of artificial silk under an improved copper-ammonia process. The property is located on Sixth St., fronting on the Chester River, comprising a number of 2-story buildings with a total of 50,000 sq.ft. of floor area. M. H. Avram, head of M. H. Avram & Co., Inc., 360 Madison Ave., New York, is president.

PITTSBURGH.—The International Cork Co. has leased the 3-story building, 25 x 70 ft., at 511 First Ave., near Grant St., for a local works.

PHILADELPHIA.—The B. F. Goodrich Rubber Co., Akron, O., has leased the plant of Reyburn Mfg. Co., 23d St. and Allegheny Ave., comprising about 100,000 sq. ft., for a local plant. The lease is for a period of years and totals $250,000. The Reyburn company, manufacturer of tags, is building a new plant at 32d St. and Allegheny Ave., and plans to occupy the structure at an early date. It will total about 250,000 sq.ft. in manufacturing area.

Texas

WICHITA FALLS. — The Keystone-Ranger Producing & Refining Co., Pittsburgh, Pa., is planning for extensions in the local plant of the Southwestern Producing & Refining Co., recently acquired. The plant has a capacity of about 1,000 bbl., and this will be increased.

CASTROVILLE.—The Gulf Portland Cement Assn., recently organized with a capital of $300,000, is planning for the construction of a large cement manufacturing plant in this section. The company is headed by L. C. Ihnken and John J. Shorp, Castroville; and W. S. Campbell, San Antonio, Tex.

WICHITA FALLS.—J. G. Kilgore and O. B. Manross are organizing a company to construct a new oil refinery at Wichita Falls, with initial capacity of about 500 barrels.

FORT WORTH.—The Invincible Oil Corp. is planning for a bond issue to total about $3,000,000. A portion of the proceeds will be used for the erection of an addition to the present oil refinery. George W. Lull is president.

Virginia

RICHMOND.—The Master Products Co., 1107 East Cary St., recently organized, has acquired a local building for its proposed new plant for the manufacture of chemical specialties, including insecticides and other products. Machinery will be installed at an early date. The company is capitalized at $50,000. E. R. Aiken is president.

West Virginia

ELLENSBORO.—The Insulite Co., manufacturer of molded composition products, has arranged for the establishment of a new local plant, 80 x 160 ft., and for which a contract recently has been let. A power house will also be installed in connection with the works. Considerable machinery will be installed for general production. Edward J. White is president and manager.

BARBOURSVILLE.—The Barboursville Clay Mfg. Co., is considering the rebuilding of the portion of its plant, destroyed by fire on April 13.

HUNTINGTON.—The Specialty Glass Co., recently organized, will construct a new local plant for the manufacture of bent glass products, such as automobile headlights, etc. Glass presses, cutting machinery and other equipment will be installed. E. W. Miller is vice-president and treasurer; William Shaw is manager.

Wisconsin

MILWAUKEE.—The L. J. Mueller Furnace Co., 197 Reed St., has awarded a contract to Paul Riesen & Sons, 1018 Humboldt Ave., for the erection of a 1-story plant at Fifteenth and Oklahoma Sts., 60 x 100 ft., to be equipped as a japanning works.

Industrial Notes

THE NATIONAL ASSOCIATION FOR THE PROTECTION OF AMERICAN RIGHTS IN MEXICO has removed its offices to 32 Bway, New York City.

THE EQUITABLE EQUIPMENT CO., a new concern, has just completed its organization for the purpose of handling locomotives, cars, machinery of all kinds, etc. Offices are located at 411 Whitney-Central Bldg., New Orleans, La.

DWIGHT P. ROBINSON & CO., INC., has recently opened branch offices in Montreal, in the Dominion Express Bldg. Alexander C. Barker, vice-president, is in charge of the office.

THE AMERICAN AMINO CORP., Garwood, N. J., has just completed its plant at Matawan, N. J., and is ready to submit samples and dyestuff intermediates.

THE RUGGLES-COLES ENGINEERING CO. has moved from 50 Church St. to 120 Bway, New York City.

FRANK D. CHASE, INC., Chicago, Ill., has just completed work on four buildings of the new West Milwaukee plant for the Chain Belt Co. of Milwaukee.

C. LORENZ AKTIENGESELLSCHAFT, Berlin, has purchased the Weld-Barfield patent rights for Germany, Poland and the former Austria-Hungary. Messrs. Lorenz have already placed an order with Automatic & Electric Furnaces, Ltd., for various parts to complete nearly 100 furnaces.

OHIO EXPORT & TRADING CO. has established its main office at 33 West 17th St., New York City, maintaining a branch office at its former headquarters in Cleveland, O. J. H. Schmidt, manager of the chemical equipment department, has his headquarters in the New York office.

THE NEW ENGLAND TANK & TOWER CO., Everett, Mass., opened a branch office on March 7 at 30 Church St., New York City. A. E. Hall, vice-president of the company, is in charge.

THE BLAW-KNOX CO., Blawknox (Pittsburgh), Pa., on April 1 opened a new sales territory in the Southwest, with headquarters in Kansas City, Mo. The new office, which is located in the Interstate Bldg., is in charge of R. B. Randall, formerly connected with the company's Chicago office, who will be known as manager of the Southwestern territory.

AMERICAN HINGE CO., incorporated under the laws of Oklahoma, has established a manufacturing plant at Memphis, Tenn. The modern cement and glass factory building, constituting the future plant, is now being constructed on the corner of Maple and Dunlap Sts. The approximate cost is $100,000. The company will manufacture a complete special line of hinges, hardware and mining specialties. All material will be furnished by the Memphis Iron & Steel Co., which has recently established a new rolling mill in Memphis. The capacity of the new plants will be 10,000 hinges per day.

METALS COATING CO. OF AMERICA, which issues licenses for the use of the Schoop metal spraying process, is now located at 495-497 North Third St., Philadelphia, Pa. Richard L. Binder is president of the company.

ARTHUR D. LITTLE, INC., Cambridge, Mass., is publishing as a reprint from the *Paper Trade Journal* the Bibliography of Papermaking Materials which was compiled by Clarence Jay West. This will be a pamphlet of 170 pages. While the company is desirous of furnishing this to all members of the Technical Association of the Pulp and Paper industry, the cost of production makes it advisable that it be sent only to those members who are really interested in the question of fibers, other than wood, used for the manufacture of paper. If, therefore, a copy of this bibliography is desired (Bibliographic Series No. 6) a post-card addressed to the firm will insure its receipt.

THE AUSTIN MACHINERY CORP. furnishes the information that on March 22 fire destroyed its Winthrop Harbor, Ill., plant, and while extensive damage was done there will not be any interference with production and prompt delivery of Austin trenching machines, backfillers, building mixers, pavers, draglines and shovels, as practically all lines of Austin machinery are also being built at the plants at Muskegon, Mich., as well as at the former plant of the Toledo Bridge & Crane Co., Toledo, O. It has been arranged to have the plants at Toledo and Muskegon increase their stock production orders to take care of the shortage which would otherwise occur through the loss of the Winthrop Harbor plant.

THE PEASE LABORATORIES, INC., 39 West 38th St., New York City, announces that Dwight Tenney, chief engineer of the Franklin Baker Co. of New York, has become associated with it as head of the newly organized department of engineering. He will continue his connection with the former company as consulting engineer, having charge of all technical development work.

THE JOSEPH DIXON CRUCIBLE CO. announces that Herbert L. Hewson has been placed in charge, as special representative, of the sale of crucible factory products in Ohio, southern peninsula of Michigan, Pittsburgh and adjacent cities and towns. Mr. Hewson first became associated with the Dixon company in 1909 in the San Francisco office.

THE STIMPSON EQUIPMENT CO., Salt Lake City, Utah, announces that Clinton Clark has been transferred to the New York office, Grand Central Palace.

SKINNER, SHERMAN & ESSELEN, INC., 248 Boylston St., Boston, Mass., has been organized and equipped to furnish counsel on all matters relating to the application of chemistry and biology to industrial operations. The new corporation has acquired the business and good will of the Boston Bio-Chemical Laboratory and will hereafter direct its activities. Prof. Samuel C. Prescott has been retained as consulting industrial biologist, and Burton G. Philbrick as laboratory director. The personnel of the corporation comprises Hervey J. Skinner, Herbert L. Sherman and Gustavus J. Esselen, Jr.

THE ENGINEERING BUSINESS EXCHANGE, New York City, announces the opening of a Southeastern branch, with offices in the McLachlen Bldg., Washington, D. C., with Marshall O. Leighton as director. Mr. Leighton was for twelve years one of the officers of the U. S. Geological Survey. Associated with Mr. Leighton will be A. C. Oliphant, who has been active in the work of Engineering Council's National Service Committee.

F. J. RYAN & CO., Philadelphia, announces that it has secured control of engineering, sales and installation of all Mircs fuel-fired equipment of the Lancaster Iron Works, Lancaster, Pa. Sales and engineering headquarters are at Philadelphia; manufacturing headquarters are at Lancaster, Pa.; New York office is retained at 501 Fifth Ave. W. W. Posey, president of the Lancaster Iron Works, has been elected a director of F. J. Ryan & Co., and A. C. Scully, secretary and treasurer of the Lancaster Iron Works, has been elected a director and treasurer.

THE BROWN HOISTING MACHINERY CO., Cleveland, O., announces the opening of a Southern office for Texas, Louisiana, Mississippi, Alabama, Georgia and Florida to be located at 530 Whitney-Central Bldg., New Orleans; Charles H. White, manager.

THE TECHNICAL SERVICE CO. has been organized, with offices in the Colonial Bldg., Allentown, Pa., to handle chemical and metallurgical problems and to provide sales service in technical equipment, materials and supplies. This company was formed by Edgar S. Genstein, who was previously metallurgist for the Treadwell Engineering Co., Easton, Pa., in chemical and metallurgical work during several years with the U. S. Navy and Army Departments.

O. S. SLEEPER & CO. announces its formation for the purpose of placing on the market a line of drying and chemical apparatus of improved design. The members of the company recently resigned from the engineering staff of the Buffalo Foundry & Machine Co. and include O. S. Sleeper, president; H. E. Neubauer, vice-president, and C. B. Brown, secretary and treasurer. Mr. Sleeper was chief engineer of the Buffalo County & Machine Co. for fourteen years. This company is prepared to furnish a line of vacuum self driers, vacuum rotary driers, direct heat driers, flaking machines, crystallizers and special apparatus.

M. P. BURT & CO. has established offices as mechanical engineer at 206 Falls Bldg., Memphis, Tenn. Included in the personnel of the new company are Milton T. Burt, mechanical engineer; J. Paul Gaines, civil engineer, and Louis G. Carlisle, architect. The company will specialize in packing house and cold storage designing and consultation on power and operating costs. Mr. Burt was formerly with the Memphis Packing Co.

THE LIMESTONE PRODUCTS CO., incorporated under the laws of Missouri, recently organized to operate quarries at Black Rock, Ark., has established headquarters in the Randolph Bldg., Memphis, Tenn. John G. Woodruff of Springfield, Mo., is president, and R. F. Alessi is secretary.

THE INTERNATIONAL PULVERIZED FUEL CORP. announces that since April 20 its general offices were located in the National City Bldg., 17 East 42d St., New York City.

THE SUPERHEATER CO. announces that on May 1 its general offices will be moved from 30 Church St. to 17 East 42d St., New York City.

THE INTERNATIONAL TRADING CO., LTD., announces the removal on May 1 to its former address, 60 B'way, New York City.

VICTOR T. GOGGIN, late New England sales manager of Fred T. Lev & Co., Springfield, Boston and New York, has severed his connection with that concern to associate himself as contracting engineer with Dwight P. Robinson & Co., Inc., New York.

O. L. MOORE, chief cement inspector of the Universal Portland Cement Co., has been appointed engineer, inspection bureau, with headquarters at 210 South La Salle St., Chicago.

THE AIRCO organization (Air Reduction Sales Co.), manufacturer of oxygen, acetylene and welding and cutting apparatus, moved its executive offices on May 1 to 342 Madison Ave., New York City. Coincident with the announcement of the general office change is another to the effect that the New York district office is located at the Airco factory, 191 Pacific Ave., Jersey City, N. J., since May. Announcement is also made that the Air Reduction Co. has obtained control of the National Carbide Corp. of Virginia, with a new plant at Ivanhoe, Va.

THE GAGE PUBLISHING CO., INC., publisher of *Electrical Record*, *Electrical Export* and *Raw Material*, located at 114 Liberty St., New York, for twenty-three years, has moved its executive and editorial offices to the Printing Crafts Bldg., 461 Eighth Ave., between 33d and 34th St.

THE EMPLOYERS MUTUAL INSURANCE CO., 61 B'way, N. Y., announces the appointment of E. C. Jacobs, formerly chief chemical risk inspector of the New Jersey Rating and Inspection Bureau, as insurance expert in charge of the inspection and underwriting of chemical risks.

THE HARRY M. HOPE ENGINEERING CO., of Boston, has established offices in the Dominion Express Bldg., Montreal, to handle its Canadian business. George W. Saunders, formerly with S. Pearson & Sons, London, is Canadian manager.

SCHWARZ LABORATORIES, analytical and consulting chemist, advises its clients of its removal on May 1 to 113 Hudson St., New York City.

THE THERMAL SYNDICATE, LTD., manufacturer of fused silica ware for chemical plant and laboratory use, announces its removal on May 1 to the New Borden Bldg., 350 Madison Ave., New York City.

THE CONVEYORS CORP. OF AMERICA, Chicago and New York, announces the appointment of Robert B. M. Wilson as sales engineer of the Chicago district. With him will be associated E. M. Wolfe. Headquarters will be maintained in the corporation's main office at 326 West Madison St., Chicago.

THE ELECTRIC FURNACE CO., Alliance, O., has just installed three Baily electric brass-melting furnaces of different size and capacity. The Bagley & Sewall Co., Watertown, N. Y., has installed a 50-kw. electric furnace with 500 lb. hearth capacity, the Alliance Brass & Bronze Co. a 75-kw. furnace with 800 lb. capacity, and the Empire Brass Works of London, Ont., a 105-kw. furnace of 1,500 lb. hearth capacity. All these furnaces are to melt yellow and red brass alloys. It is also announced that the Lorain Steel Co., Johnstown, Pa., is installing a 200-kw. Baily electric furnace for heat-treating railroad bolts and similar parts. This furnace is of the continuous pusher type with motor-operated control mechanism and will have a capacity sufficient to heat-treat 14 tons of material per day.

ELECTRIC FURNACE CONSTRUCTION CO., Philadelphia, Pa., has received an order from the Sociedad Espanola de Construccion Naval for a new design of electrically heated car-type annealing furnace for heat-treating large steel ingots and forgings. It will be 6.8 m. long by 4.75 m. wide by 414 m. high, and will heat a charge of 60 tons of steel to 1,700 deg. F. every 24 hours. T. H. Watson & Co., Ltd., Sheffield, England, and the Electric Furnace Construction Co., Philadelphia, announce that arrangements have been made with the General Combustion Co., of Canada, Ltd., New Kirks Bldg., Montreal, to handle, build and sell their various electric smelting, melting and refining furnaces in Canada. The Canadian rights of the Greaves-Etchells type of furnace are also included in the arrangements made.

New Companies

The Central Paper Co., Newark, N. J., has been incorporated with a capital of $50,000 to manufacture and deal in paper products. The incorporators are Benjamin S. Berkowitz, Morris W. Shapiro and Louis Weiss, 148 Mulberry St.

The Imperial Bearing Bronze Co., Flushing, L. I., has been incorporated with a capital of $20,000 to manufacture brass and bronze products. The incorporators are L. Osabon, J. M. Partmann and S. O. Wood, Jamaica, L. I.

The Missouri Oxide & Chemical Co., New York, N. Y., has been incorporated under Delaware laws with a capital of $800,000 to manufacture chemicals and chemical byproducts. The company is represented by Arthur W. Britton, 65 Cedar St.

The Eastern Tablet Co., Boston, Mass., has been incorporated with a capital of $775,000 to manufacture paper products. The incorporators are Alexander W. Murray, Wellesley Farms, Mass.; Marcus E. Mahon, Quincy, Mass.; and Ray Henry, Cambridge, Mass.

The Riverway Mfg. Corp., Cambridge, Mass., has been incorporated with a capital of $50,000 to manufacture chemicals and byproducts. The incorporators are A. Hollander, Brookline, Mass.; Cyril M. and J. Hollander, Boston.

The Pabst Chemical Corp., 324 Sherman St., Chicago, Ill., has been incorporated with a capital of 200 shares of stock, no par value, to manufacture chemicals and affiliated products. The incorporators are William W. Allan, George W. Andress and Theodore Harbeck.

The Holyoke Gummed Products Co., Holyoke, Mass., has been incorporated with a capital of $100,000 to manufacture paper, strawboard and kindred products. The incorporators are Charles F. Moriarty, Nashua, N. H.; Martin J. Judge and Maurice J. Moriarty, South Hadley Falls, Mass.; and Charles B. Dunbar, Holyoke.

Hanson, Dunn & Co., Inc., Providence, R. I., has been incorporated with a capital of $20,000 to manufacture soaps and kindred products. The incorporators are Louis W. and John F. Dunn, and Samuel Hanson, 11 Evergreen St., Providence.

The Van Siclen Chemical Laboratories, Inc., Brooklyn, N. Y., has been incorporated with a capital of $100,000 to manufacture chemicals and chemical byproducts. The incorporators are J. T. Repton, N. Handler and W. H. Birken, I. Berson, 16 Court St., represents the company.

The Winamac Cement Products Co., Winamac, Ind., has been incorporated with a capital of $25,000 to manufacture cement specialties. The incorporators are Chris Hansen, John Kruzick and George Kurzick, Winamac.

The Flexible Cork Co., Jersey City, N. J., has been incorporated with a capital of 7,400 shares of stock, no par value, to manufacture cork products. The incorporators are H. A. Black, Alfred F. McCabe and John R. Turner, 15 Exchange Pl.

The Edward R. Bule Chemical Corp., New York, N. Y., has been incorporated with a capital of $30,000 to manufacture soaps, cleaning preparations and other chemical products. The incorporators are Edward R. Bule, C. F. Newinger and V. Mast. The company is represented by Lee, Aron & Wise, 7 Dey St.

The Kane Oil Refining Co., Brooklyn N. Y., has been incorporated with a capital of $25,000 to manufacture refined oil products. The incorporators are W. A. Kane, Sr. and Jr., and H. S. Cook, 38 Park Row.

The Oil & Supply Co. of Illinois, 116 South Michigan Ave., Chicago, Ill., has been incorporated with a capital of $20,000 to manufacture refined oils. The incorporators are H. O. Nottingham, Frank B. Page and James E. Hauronic.

The C. M. Carroll Paper Co., New Bedford, Mass., has been incorporated with a capital of $25,000 to manufacture paper products. Charles M. Carroll, 50 Page St., is president and treasurer; G. E. and Milton E. Carroll are directors.

The Star Oil Co., Los Angeles, Cal., has been incorporated with a capital of $500,000 to manufacture petroleum products. The incorporators are W. A. and E. M. Mathias, and R. E. Burbank, Los Angeles.

The Pure Air Corporation, New York, N. Y., has been incorporated with a capital of $100,000 to manufacture chemicals and chemical byproducts. The incorporators are S. G. Geler and J. S. Friedman, 277 B'way.

The Robert Wysley Co., 91 River St., Hoboken, N. J., has been organized to manufacture chemicals and affiliated products. Nicholas Noggi heads the company.

The Universal Chemical Co., Richmond, Va., has been incorporated with a capital of $100,000 to manufacture chemicals and chemical byproducts. The incorporators are H. L. Jones, Norfolk, Va.; and J. McD. Woolford, Richmond.

The Drown Specialty Co., Worcester, Mass., has been incorporated with a capital of $10,000 to manufacture paper products. William L. Drown is president; and Oscar L. Drown, 6 Field Way, treasurer.

The Universal Shale Products Co., Buffalo, N. Y., has been incorporated with a capital of $500,000 to manufacture refined mineral oil products. The incorporators are A. Adamozak and J. Janowski. Falk, Phillips & Schlenker, Morgan Bldg., represent the company.

The Liberty Paint Co., 1400 First National Bank Bldg., Chicago, Ill., has been incorporated with a capital of $20,000 to manufacture paints, oils, etc. The incorporators are Frank B. Page and associates. Winston, Strawn & Shaw, address noted, represent the company.

The Crown Die Casting Co., Detroit, Mich., has been incorporated with a capital of $25,000 to manufacture die castings and kindred metal products. The incorporators are R. Frank Ward, Mt. Morris, Mich.; John F. Goude and V. E. Thompson, Flint, Mich.

The Peel Chemical Corp., New York, N. Y., has been incorporated with a capital of $200,000 to manufacture chemicals and chemical byproducts. The incorporators are A. B. Johnson, R. P. Dicks and A. David. Platt & Field, 120 B'way, represent the company.

The Modern Lubricating Co., Minneapolis, Minn., has been incorporated with a capital of $100,000 to manufacture lubricating oils and kindred products. The incorporators are A. N. and D. Peever, and George H. Clarke, Minneapolis.

The Hide & Leather Co., Boston, Mass., has been incorporated with a capital of $200,000 to manufacture leather products. Ralph W. Dunbar is president, and Harrison M. Davis, 75 Ames Bldg., treasurer.

The Pecos Valley Refining Co., Los Angeles, Cal., has been incorporated with a capital of $100,000 to manufacture refined oils. The incorporators are L. K. Adams, John C. Gillkam and George W. Davis, Los Angeles.

The Bohemia Brick & Tile Co., Houston, Tex., has been incorporated with a capital of $125,000 to manufacture brick, tile and other burned clay products. The incorporators are A. T. Eddington, Otto Jetal and James Pokorny.

The American Celutex Corp., New York, N. Y., has been incorporated with a capital of $200,000 to manufacture celluloid and other composition products. The incorporators are A. Burke, I. L. Goldberg and C. S. Aronstan, 100 B'way.

The Merle Sears Paper Box Co., 740-42 Main St., Danville, Ill., has been incorporated with a capital of $60,000 to manufacture paper cartons, containers, etc. The incorporators are H. N. and Merle Sears, and George D. Johnson.

The Producers' Petroleum Co., Duncan, Okla., has been incorporated with a capital of $250,000 to manufacture petroleum products. The incorporators are John O'Donahue, W. M. McGregor and C. E. McCutchen.

The Belco Drug & Extract Co., 790 Broad St., Newark, N. J., has been incorporated with a capital of $25,000 to manufacture chemicals, drugs, etc. The incorporators are Samuel M. Hollander, S. Kneip, Newark; and E. Fairhurst, Kearny, N. J.

The Huntington-Pacific Oil & Refining Co., Los Angeles, Cal., has been incorporated with a capital of $250,000 to manufacture petroleum products. The incorporators are J. J. Eiseman, J. H. Roth and George E. Benson.

The Lowry Mfg. Co., Winchester, Ky., has been incorporated with a capital of $10,000 to manufacture chemicals, washing powder and kindred products. The incorporators are E. A. and S. M. Lowry, and Edward C. Epperson, Winchester.

The Chief Chemical Laboratories, Inc., Brooklyn, N. Y., has been incorporated with a capital of $6,000 to manufacture chemical specialties. The incorporators are S. Krasner and H. Shorenstein. Caldwell & Polhemus, 50 Church St., New York, represent the company.

The Standard Clay Co., Brazil, Ind., has been incorporated with a capital of $300,000 to manufacture bricks, tile and other burned clay products. The incorporators are Albert F. Price and Edwin T. Norris, Brazil; and John H. Wright, Indianapolis, Ind.

The Reliable Glass Co., 1816 West Division St., Chicago, Ill., has been incorporated with a capital of $6,000, to manufacture glassware. The incorporators are Harry Resnick, Samuel Sless and Jacob Schulemsohn.

The Fairmont-Somerset Oil Co., Fairmont, W. Va., has been incorporated with a capital of $200,000 to manufaccture petroleum products. The incorporators are Osman E. Swartz, A. J. Colburn and W. R. Dougan, Fairmont.

The Greenport Brick Corp., Greenport, N. Y., has been incorporated with a capital of $300,000 to manufacture brick and other burned clay products. The incorporators are J. Briskman, S. Bitterman and E. R. Greenstein. Bitterman & Hecht, 305 B'way, New York, represent the company.

Coming Meetings and Events

American Association of Engineers will hold its seventh annual convention at the Hotel Lafayette, Buffalo, N. Y., on May 9, 10 and 11.

American Institute of Chemical Engineers will hold its spring meeting June 20 to 24 at Detroit. Industrial excursions will be made to Ann Arbor, Saginaw, Midland and Bay City.

American Leather Chemists Association will hold its eighteenth annual meeting at the Hotel Ambassador, Atlantic City, June 9, 10 and 11.

American Mining Congress and National Exposition of Mines and Mining Equipment will hold its twenty-fourth annual convention in the Coliseum, Chicago, Oct. 17 to 22.

American Oil Chemists' Society (formerly the Society of Cotton Products Analysts) will hold its twelfth annual meeting in Chicago May 16 to 17. Headquarters will be at the Congress Hotel.

American Society of Mechanical Engineers will hold its spring meeting at the Congress Hotel, Chicago, May 23 to 26.

American Society for Steel Treating will hold its third annual convention and exhibition Sept. 19 to 24 at Indianapolis.

American Society for Testing Materials will hold its 1921 annual meeting in the New Monterey Hotel, Asbury Park, N. J., during the week of June 20.

American Zinc Institute will hold its annual meeting in St. Louis May 9 and 10.

Colorado Scientific Society, Denver, Col., will hold its 343d regular meeting May 7, 1921, in the Colorado State Museum Bldg., Denver. Arthur J. Hoskins will address the meeting. His subject is "Colorado's Oil-Shale Industry."

British Iron and Steel Institute will hold its spring meeting May 5 and 6, at the Institution of Civil Engineers, Great George St., S. W. 1, London, England.

The National Exposition of Chemical Industries (Seventh) will be held during the week of Sept. 12, in the Eighth Coast Artillery Armory, New York City.

National Fertilizer Association will hold its twenty-eighth annual convention at the Greenbrier Hotel, White Sulphur Springs, W. Va., the week beginning June 20.

New Jersey Chemical Society holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

Stamford Chemical Society, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month; except June, July, August and September.

Tanners' Council of the United States will hold its annual spring convention at the Hotel Traymore, Atlantic City, May 5 and 6.

The following chemical societies will meet at Rumford Hall, Chemists' Club, New York City, as follows: May 6, American Chemical Society, Nichols Medal award; May 13, Société de Chimie Industrielle, joint meeting with American Chemical Society, Society of Chemical Industry and American Electrochemical Society; May 20, Society of Chemical Industry; June 10, American Chemical Society.